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Hanford Tank Farms Vadose Zone Monitoring Project

Radionuclide Assessment System Logging System Operating Procedures

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Hanford Tank Farms Vadose Zone Monitoring Project
Radionuclide Assessment System Logging System Operating Procedures

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1.0 Introduction

During fiscal year (FY) 1995, the U.S. Department of Energy Grand Junction Office (DOE-GJO) was tasked to review the methods used at Hanford to detect leaks from individual single-shell tanks (SSTs). On the basis of this review, it was determined a medium-resolution spectral gamma logging system was needed to provide external monitoring of tanks that would supplement the in-tank leak detection being conducted. During FY 1996, DOE-GJO designed and fabricated the Radionuclide Assessment System (RAS) specifically for performing routine monitoring. The objective of the design was to deliver a logging system capable of obtaining measurements over the wide range of radionuclide concentrations expected around the SSTs. Once the Hanford Tank Farms vadose zone baseline characterization was completed in FY 2000, DOE-GJO was tasked by the U.S. Department of Energy Office of River Protection (DOE-ORP) to complete the deployment of the system and initiate a monitoring program.

1.1 Purpose

The purpose of the Hanford Tank Farms Vadose Zone Monitoring Project is to acquire spectral gamma measurements from borehole surrounding the SSTs that can be compared to baseline spectral gamma measurements that were collected during the vadose zone baseline characterization conducted between 1995 and 1999. The baseline characterization identified the nature and extent of contamination associated with gamma-emitting radionuclides in the SSTs using data acquired from existing boreholes. The RAS will be used to monitor gamma-ray-emitting radionuclides that are present as contaminants in sediments surrounding monitoring boreholes in the Hanford Site single-shell tank farms. The monitoring project is designed to 1) identify changes in the distribution of vadose zone contamination, 2) track gamma-emitting radionuclide contaminant movement, and 3) identify or verify future tank leaks.

1.2 Objective

This logging procedure provides guidelines for conducting safe borehole logging operations with the RAS and procedures for acquiring consistent, quality data. Proficiency in conducting logging operations will be achieved by implementing these procedures and through hands-on training.

For operators familiar with RAS procedures, a summary of the procedures is provided in Appendix A.

2.0 Equipment Description

2.1 RAS Vehicle

The RAS consists of a 2002 Chevrolet 2500 HD LS Club Cab 4X4 Duramax diesel pickup truck (HO-1H-877), (E-37912), that has been fitted with a camper shell equipped with side storage boxes (Figure 1). The truck is powered by a V-8 diesel motor and will be operated with standard and usual motor vehicle operating procedures. The owner's manual for this vehicle is kept on file at the Stoller Richland Office.

2.2 Mount Sopris Winch

An electric winch, manufactured by Mount Sopris Corporation, is a self-contained unit that transports a sonde up and down a borehole via a seven-conductor 0.25-inch (in.)-diameter armored cable during logging operations (Figure 2). The winch is mounted in the truck bed. A winch controller controls the direction (up and down) of the logging cable and the spooling speed of the winch drum.

2.3 Sodium Iodide (NaI) Detectors

The RAS uses three sodium iodide (NaI) detectors that are individually connected to a common telemetry section; detector and telemetry sections combined constitute the logging sonde. Each detector is designed to measure different intensities of gamma flux. The specifications for each of the detectors are provided in the following table:

Detector Description	Crystal Size (in.)	Shielding	Sonde Diameter (in.)	Sonde Length (in.)[1]	Sonde Weight (lbs.)[1]	Detector Resolution[2]
Large (L)	3 x 12	None	4	60	56.75	< 8%
Medium (M)	1.5 x 2	None	3	52	32.25	< 8%
Small (S)	1 x 1	2 in. lead above and below detector.	3	52	43.25	< 8%

[1] Length and weight of entire sonde, including PHA/Telemetry Section.
[2] At 662 keV.

Individual detectors consist of several components including the NaI crystal, photo-multiplier tube, high-voltage power supply, and ancillary circuitry that are arranged inside a stainless steel housing. A line scribed around the bottom outside surface of each housing marks the center of the NaI crystal; this line is the zero depth reference for the detector. Detectors are labeled, and when not in use, are secured in a vertical tool rack that is located in the truck bed. The detectors and storage rack are shown in Figures 2 and 3.

Figure 1. Radionuclide Assessment System (RAS) Vehicle

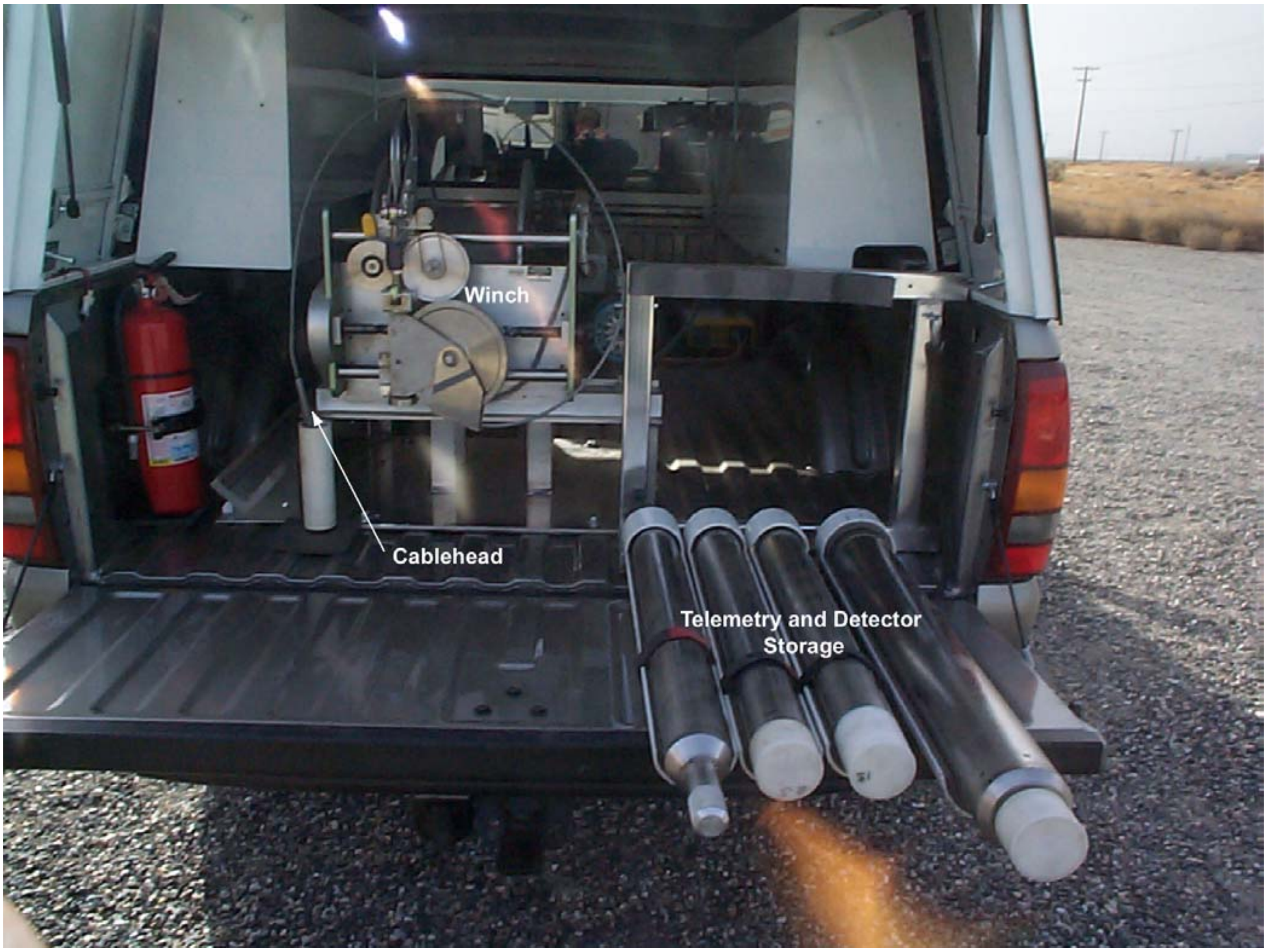

Figure 2. Rear View of the RAS Showing the Winch and Tool Components

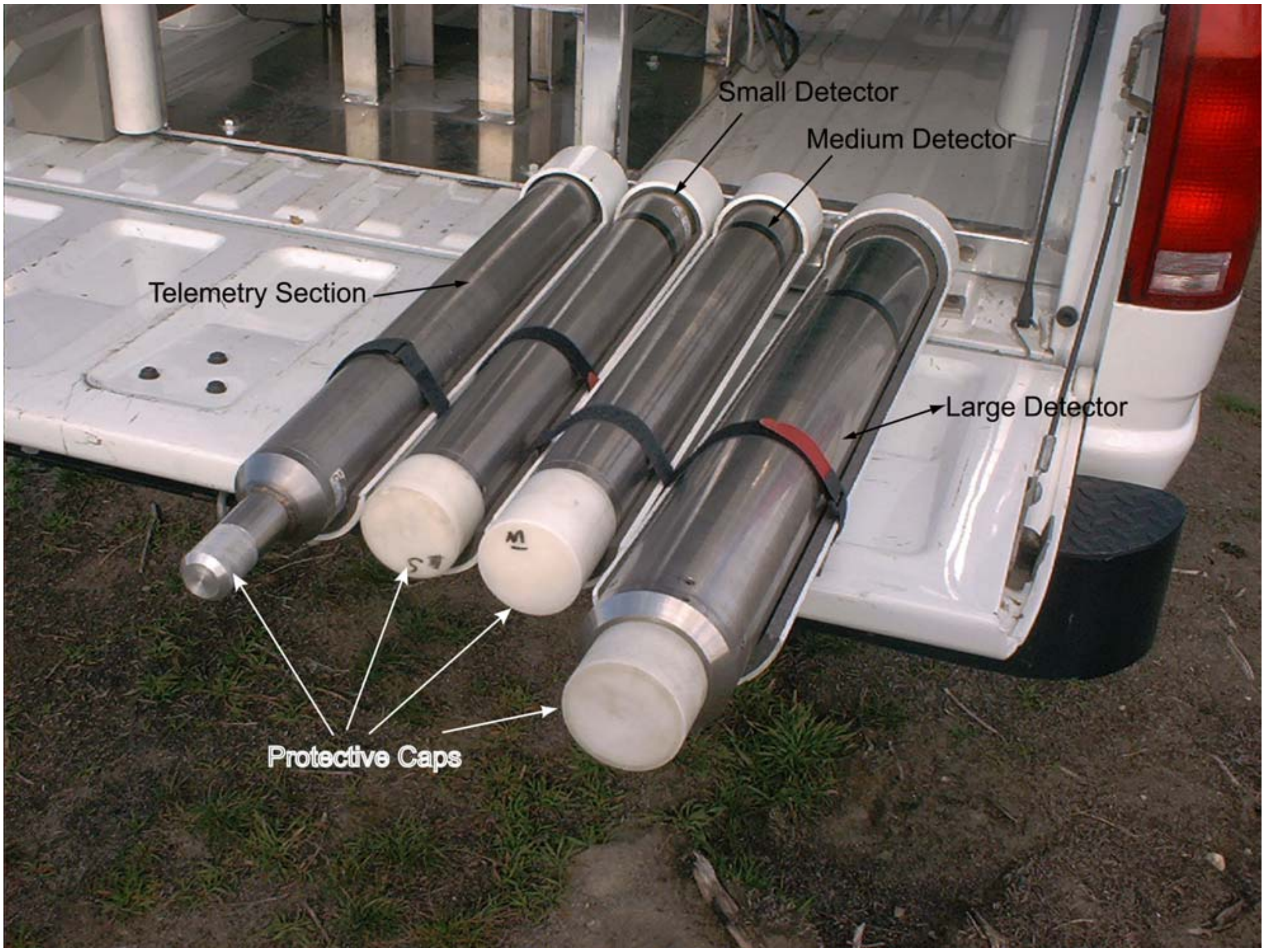

Figure 3. RAS Detectors and Telemetry Section Arranged in the Tool Rack

2.4 Telemetry-Section

The telemetry-section is a common component to all three detectors and was fabricated to hold the pulse-height analyzer (PHA) and the electrical data transmitting and receiving circuitry (Figure 3). The telemetry section digitally transmits full-spectrum data up the borehole to the logging computer. Pulse-height data are collected down-hole to maximize performance of the RAS. Joined together, the telemetry section and detector constitute the RAS logging tool or sonde.

2.5 ProSine Power Inverter

A true sine wave alternating current (AC) output inverter (model ProSine 1000/1800), manufactured by Statpower Technologies Corporation, supplies 110-volt AC electrical power to the RAS and ensures that all AC loads operate efficiently and correctly. The ProSine inverter, which is located in the truck bed (Figure 4), is designed to deliver sine wave voltage as if operating from a grid or utility supplied power source. It operates by converting the 12-volt direct current (DC) power from the vehicle batteries and alternator to 110-volt AC. A switch controls the output (ON/OFF) of the inverter, and a liquid crystal display (LCD) shows current input and power output from the inverter when a load is being applied. A multi-segment bar graph displays actual output power in watts from the inverter when a load is being operated.

2.6 Mast

A mast designed to fit over the boreholes supports the logging sonde and cable during logging. The mast is constructed from aluminum and consists of five components:

1) Mast base with 6-in.-diameter casing adapter
2) Mast
3) 8-in.-diameter casing adapter
4) Mast base with 4-in.-diameter casing adapter
5) Borehole plug

A single sheave wheel is attached to the mast base and mast pole to align the logging cable with the winch and borehole opening. The mast components are illustrated in Figure 5.

2.7 Logging Computer

RAS logging operations are controlled with a Solo 5300 laptop personal computer (PC) manufactured by Gateway Corporation. The PC, which utilizes the Microsoft Windows 98 operating system, controls the PHA, stores the log data for later processing, and analyzes/displays the data to allow the operator to judge the data quality. Depth data and PHA/spectral data are assembled within the PC and stored internally on a hard disk. Figure 6 shows the location of the PC.

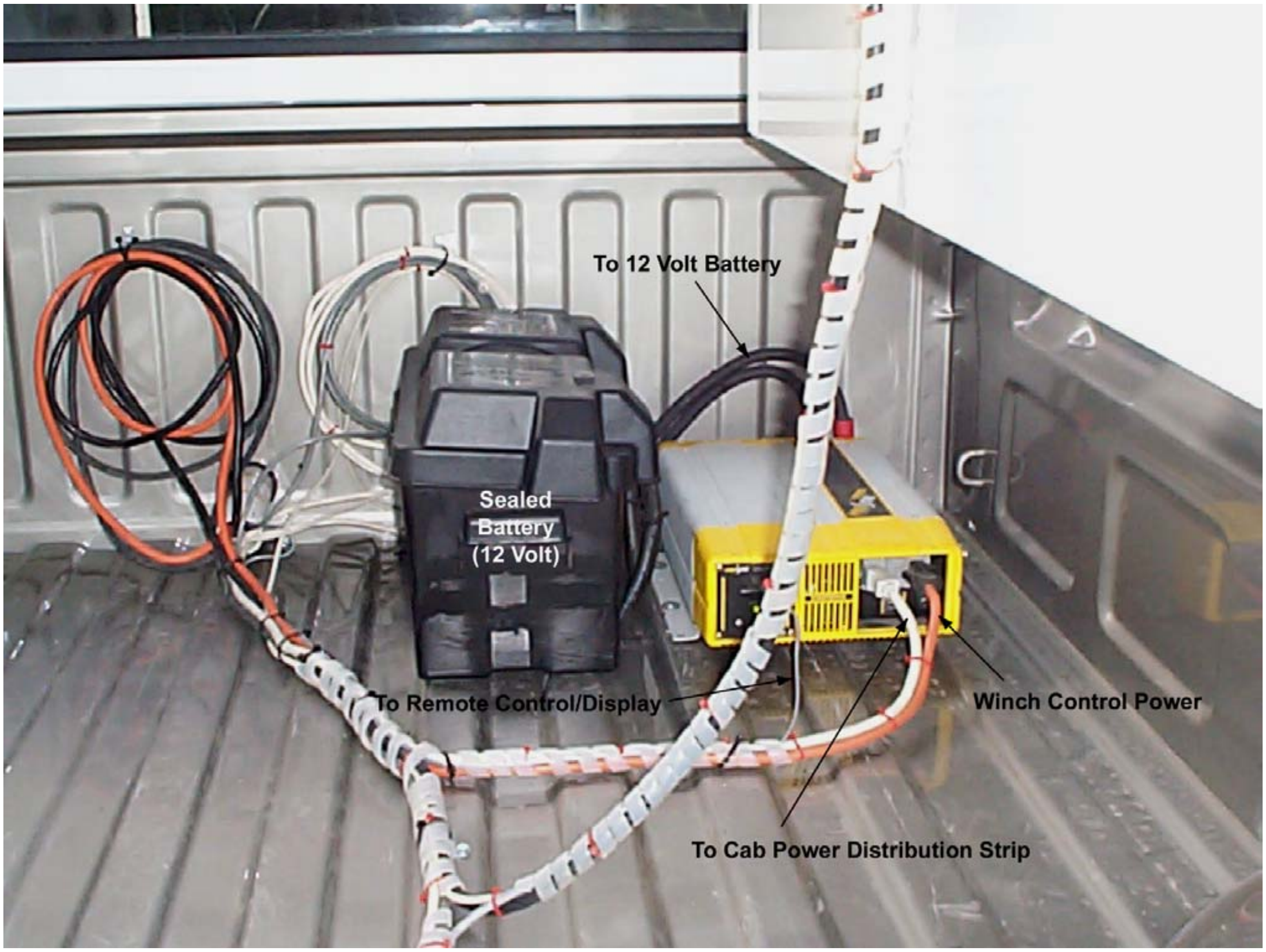

Figure 4. ProSine Power Inverter

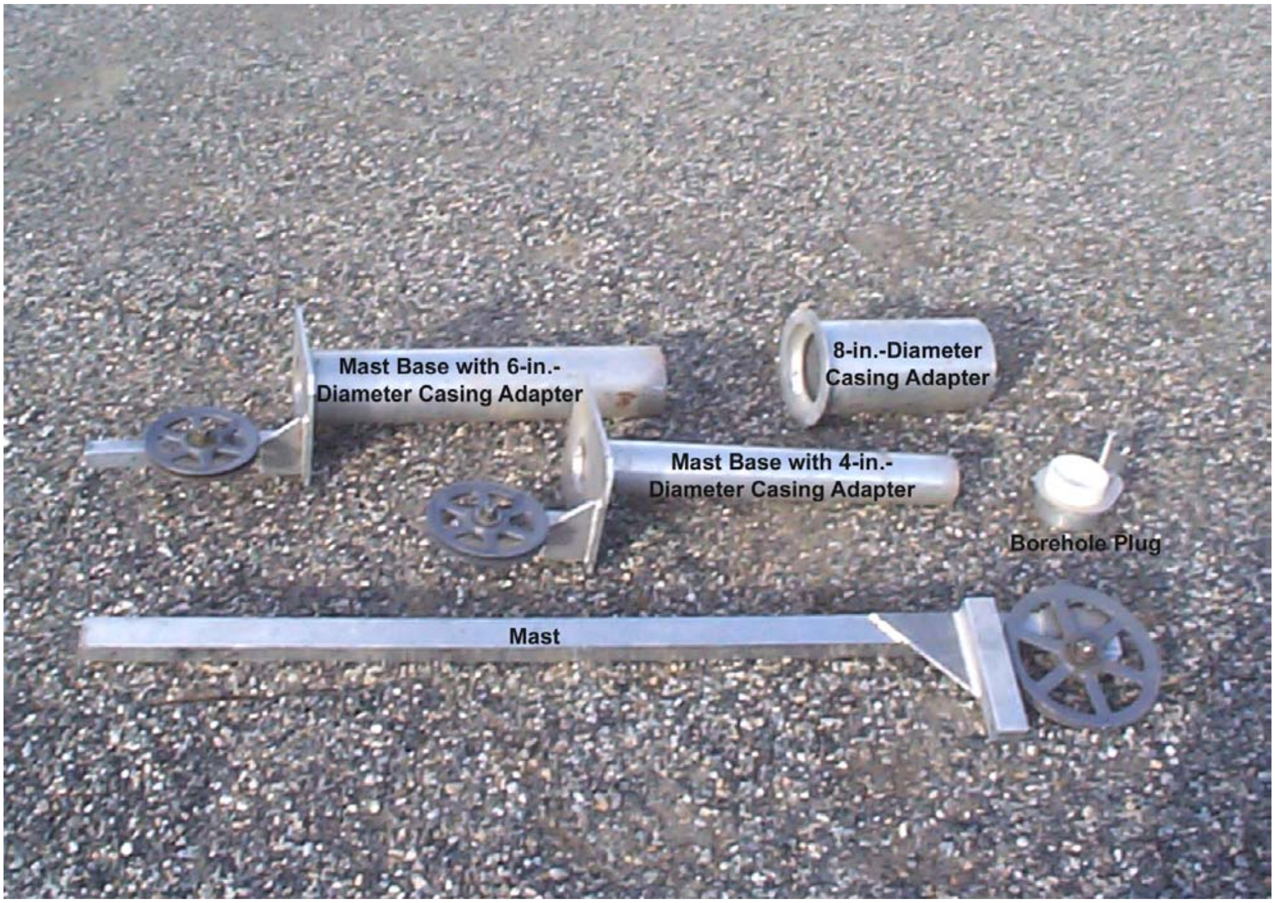

Figure 5. Mast Components

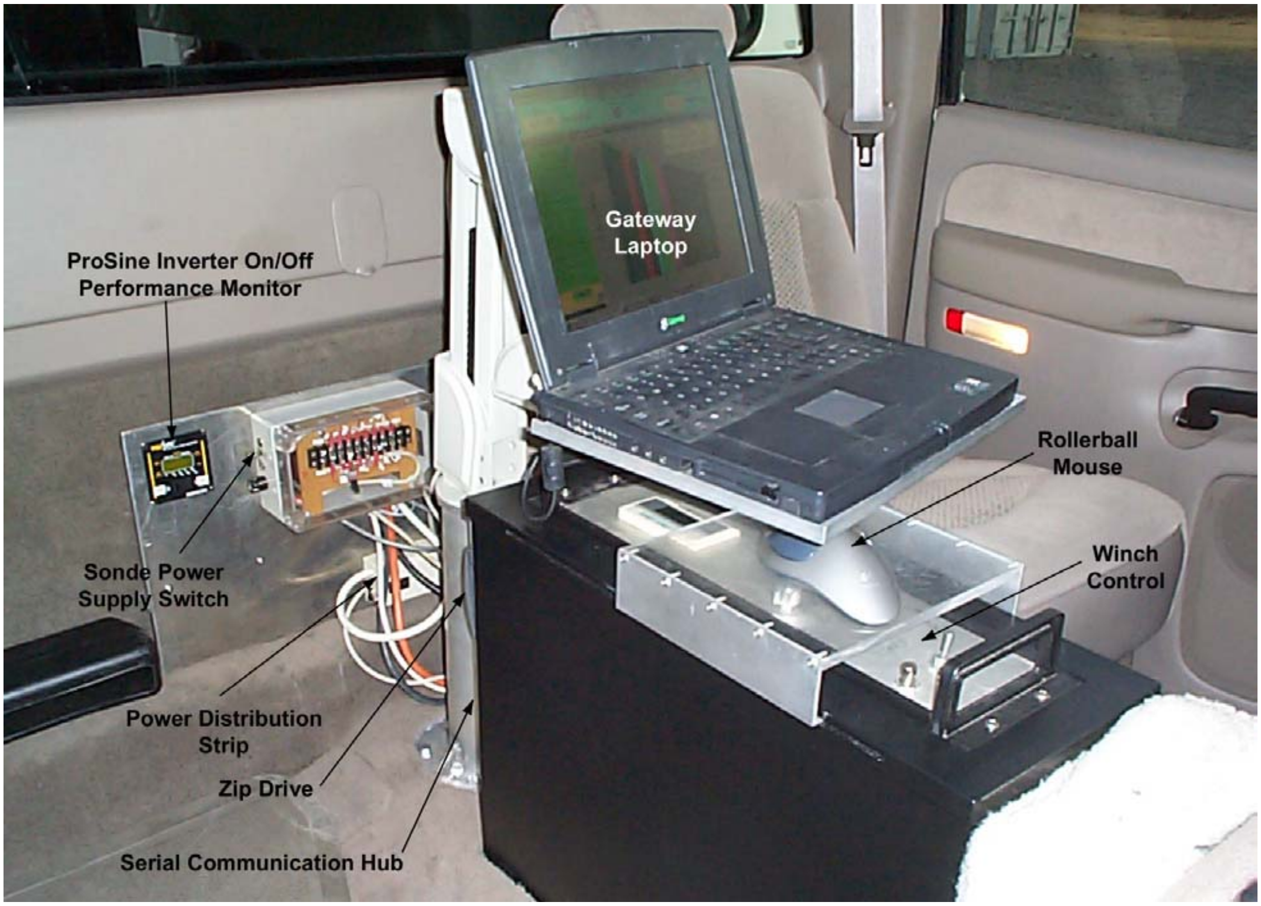

Figure 6. RAS Cab Equipment Configuration

2.8 Zip Drive

Spectral data are transferred to a zip disk at the completion of logging. A 250-megabyte zip drive, manufactured by Iomega, is installed on the RAS and is located in the logging cab. Data transfer is performed through an interface of software and hardware between the hard drive on the PC and the zip drive. The transferring process is fully automated through the logging software by using a single command. Figure 6 shows the location of the zip drive.

2.9 Micro Wiz Multifunction Counter

A multifunction counter, manufactured by Micro Wiz, is the interface between the PC and the Mount Sopris winch (Figure 7). A depth encoder, located on the winch, sends electrical signals to the counter, which then communicates with the logging computer during logging operations. The digital depth odometer is located near the winch in the truck bed and faces the logging cab for easy viewing.

2.10 AEA Technology KUTh Field Verifier

A low-intensity (exempt quantity) gamma-ray source, called a KUTh Field Verifier, is used to record gamma-ray spectra at the start of each day to assess system performance. The KUTh Field Verifier is manufactured by AEA Technology QSA, Inc. (AEA) and identified by serial number 134. AEA certifies that the verifier contains potassium-40 (^{40}K), uranium-238 (^{238}U), and thorium-232 (^{232}Th) in such minute quantities that the U.S. Nuclear Regulatory Commission and the radiation control agencies of the various states do not impose licensing requirements. The quantity of radioisotopes and the dose rate at the surface of the verifier are below limits for limited quantity radioactive material established by the U.S. Department of Transportation.

The verifier is approximately 11 in. in diameter by 13.5 in. in length. The KUTh mixture is encapsulated in a standard aluminum clam-shell configuration with a 4-in.-diameter access hole in the center; the verifier weighs approximately 64 lbs. The following table is a summary of the source test report received from the AEA with the verifier.

Isotope	**Activity**	**Concentration**
^{40}K	1.662 µCi, 61.531 kBq	11.7%
^{238}U	0.46 µCi, 17.02 kBq	80 ppm
^{232}Th	0.331 µCi, 12.247 kBq	180 ppm

The KUTh Field Verifier, which is permanently mounted in the bed of the RAS vehicle by a metal mounting bracket, is located at the end of a tool tray that facilitates positioning the logging tool in the verifier for pre-survey calibrations (Figure 8). The locking camper shell and the mounting bracket provide security for the KUTh Field Verifier. An Onsite Routine Radioactive Shipment Record (ORRSR), issued by site transportation, safety and radiological control will accompany the KUTh verifier at all times.

Figure 7. Micro Wiz Multifunction Counter

Figure 8. AEA Technology KUTh Verifier

3.0 Vehicle Operation

3.1 Vehicle Inspection

Before operating the RAS vehicle, the driver will be satisfied that the motor vehicle is in safe operating condition. The driver is responsible for performing a motor vehicle inspection at least once per day before truck movement. A RAS *Daily Inspection Log* (Figure 9) will be completed indicating that an inspection has been performed. Documentation and inspections will comply with the requirements detailed in the *Hanford Tank Farms Vadose Zone Monitoring Project Preventive Maintenance Procedure for the Radionuclide Assessment System* (DOE 2005). Vehicle defects and deficiencies should be immediately reported to the S.M. Stoller Corp. point of contact before the RAS is utilized.

3.2 Vehicle Start Sequence

Correctly starting the truck's diesel motor follows a two-step process:

1) Start by turning the ignition key to the RUN position, but stopping before engaging the starter motor.

2) Wait and observe that a steady amber warning light on the instrument panel illuminates that says, "WAIT TO START." This waiting period allows the engine glow plugs to heat the combustion chambers to enhance starting. The waiting period expires less than 20 seconds before the warning light goes off, which is the signal to the driver that the starter motor can be fully engaged. This light may not come on if the engine is hot, indicating the engine is ready to start. Refer to the vehicle owner's manual for additional information.

Note: When the truck's motor is running, the vehicle headlights are always ON regardless of whether the headlight switch is ON or OFF. This is a built-in safety feature from the manufacturer observed on many cars and trucks. To turn the lights OFF, the emergency brake must be engaged. When the emergency brake is engaged, a red warning light on the vehicle's instrument panel will illuminate as a reminder to the driver that the emergency brake is set.

During logging operations, the emergency brake will be engaged and the transmission placed in the PARK position. A set of wheel chocks will be placed in front of and behind one wheel after the vehicle is positioned over a borehole. The wheel chocks can be stored in the side storage compartments when not in use.

RAS Vehicle Daily Inspection Log

This Inspection Log may be duplicated as necessary.

DATE	MILEAGE	ENGINE RUN HRS	ENGINE FLUIDS CHECK (√)	UNDER HOOD INSPECTION (√)	WALK AROUND VEHICLE INSPECTION (√)	ALL LIGHTS (√)	RAS VEHICLE OPERATOR SIGNATURE
Discrepancies and Deficiencies: (More space is available on back of Inspection Log.)							

Figure 9. RAS Daily Inspection Log

4.0 Detectors, Telemetry-Section, and the Cablehead

This section describes the detectors and telemetry section, and cablehead assembly and storage. The individual detectors and telemetry pieces are referred to as a sub in this procedure. Joined together, the subs constitute the RAS logging tool or sonde.

4.1 Protective Caps

Custom-made caps manufactured from aluminum and hard plastic are provided to protect the ends of the subs and the cablehead. These protective caps (see Figure 3) cover machined areas and electrical contacts that have the potential to be damaged by repeated handling or misuse. The protective caps should be used at all times when the subs are in storage or not in use.

4.2 Pin and Slip Ring Contacts

The subs were manufactured using different electrical contacts. The detectors have spring-loaded, pin-type contacts and the telemetry sub has circular slip ring contacts (Figure 10). The pins on the detectors extend out from the subs, exposing them to possible breakage. The pins are delicate and can be easily sheared off or broken when assembling the tools if not handled properly.

4.3 "O" Ring Seals

Three "O" rings are used to seal the mating surfaces between the subs and cablehead. These "O" rings require daily inspections.

Two small diameter "O" rings are located on the end of the cablehead, and one larger diameter "O" ring is located on the mating surface on the bottom of the telemetry sub. The "O" ring on the telemetry sub falls out of place easily when either the protective cap or detector is removed. Clean the components and contact surfaces as necessary.

Inspect that the "O" rings are present and their condition is satisfactory. For an "O" ring check, look for wear-and-tear, nicks, cuts, breaks, dirt, or debris. If the "O" rings are damaged, replace them before making the final assembly. In addition, before making a sub connection, conduct a thorough inspection of the pieces and areas that will be threaded together. Wipe or clean all surfaces as necessary. Figures 10 and 11 show the "O" ring seals on the telemetry section and cablehead, respectively.

A small amount of Lubriplate (white grease) should be applied on the "O" rings, cable nut, and threaded areas after cleaning to prevent the threads from galling. Galled threads will tend to stick, and, in severe instances, galled threads weld together and ruin mating components.

The RAS will be equipped with spare "O" rings for the routinely used components. However, if additional "O" rings are needed, notify the Stoller point of contact.

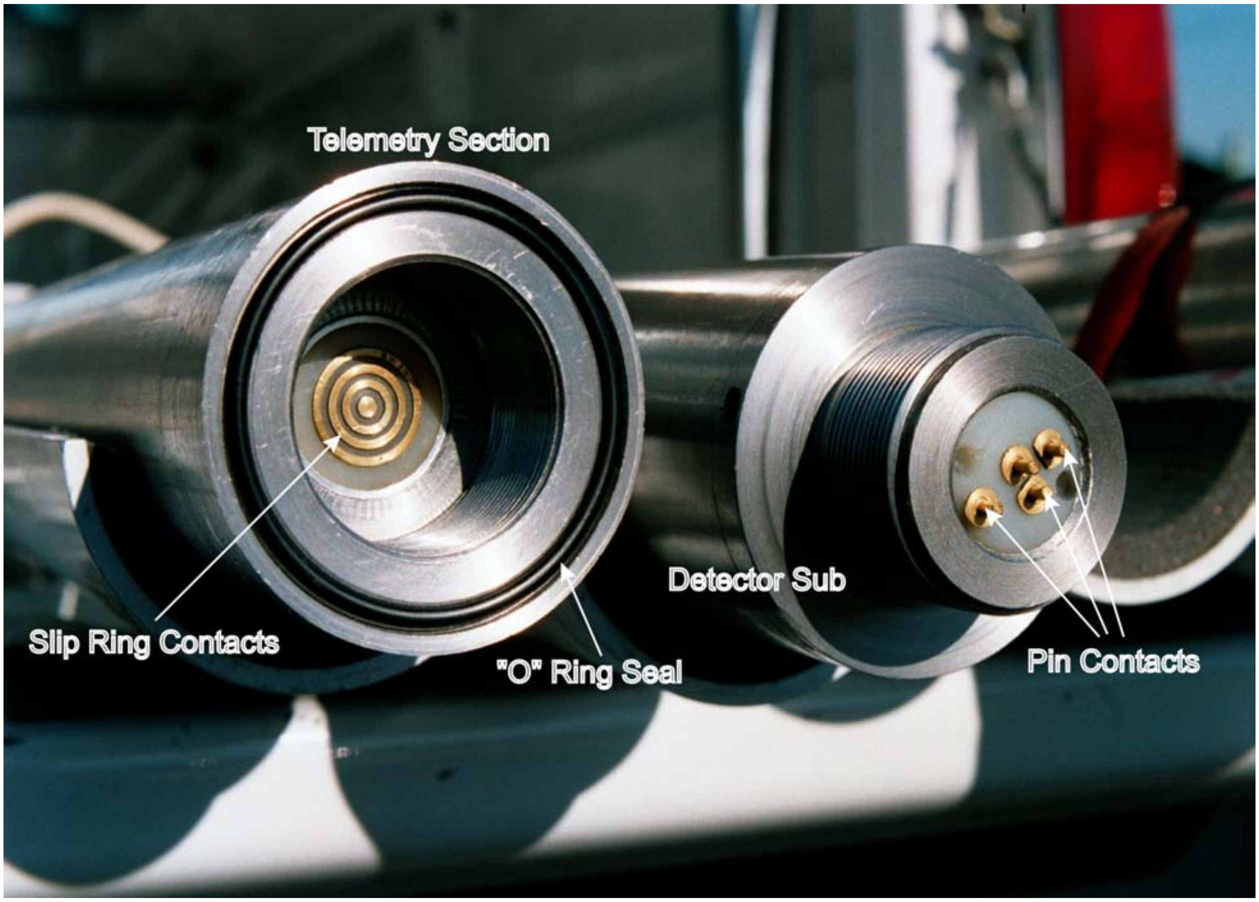

Figure 10. Telemetry Section and Detector Subs Showing the Pin and Slip Ring Contacts

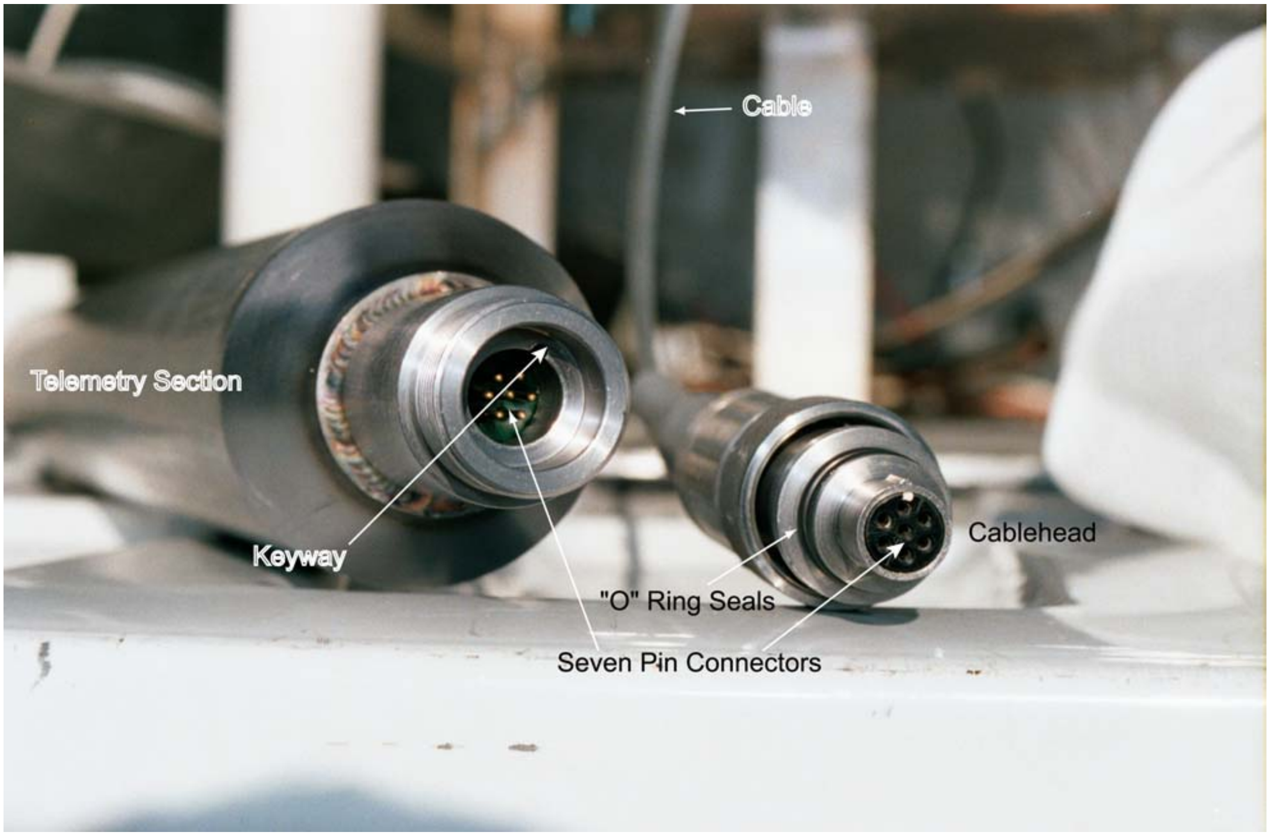

Figure 11. Telemetry Section and Cablehead Showing “O” Rings, Keyway, and Connectors

4.4 Cablehead

The cablehead (Figures 11 and 12) is utilized to connect the logging cable to the sonde. A quick-change nut on the cablehead is used to connect the cablehead to the sonde. Two "O" ring seals (described in the previous section) are located on the cablehead. A protective cap and holding device are provided to cover the end of the cablehead and to secure the cablehead when not in use.

4.5 Connecting the Detector, Telemetry, and Cablehead

The RAS logging sonde is comprised of three basic pieces:

1) NaI detector
2) Telemetry section
3) Cablehead

Before assembly, inspect the components for wear-and-tear and damage. Report any problems to the Stoller point of contact. It is important to follow the two steps below in order.

1) Detector and Telemetry Connection:

   Select one of the detector subs (S, M, or L) and connect it to the telemetry section. To attach the detector sub to the telemetry sub turn the detector clockwise; to separate the subs, turn the detector counterclockwise. To assist in assembling the different subs, a V-shaped tool tray is permanently affixed to the truck bed. The tool tray and hole in the KUTh Field Verifier are aligned for easy use. Remove the protective caps, inspect the threads and "O" rings, and lay the two subs in the tool tray. Ensure that the tool power is turned OFF, then turn the subs together and hand-tighten them to a snug and secure fit. Care must be taken not to shear the exposed connector pins protruding from the detector sub.

Note: The sub containing the detector is very fragile; avoid any sharp blows.

2) Cablehead and Telemetry Connection:

   Identify the keyway on the cablehead and the slot in the telemetry sub, and inspect it for damage. Align the cablehead and telemetry sub before joining, or damage could result. Once the pieces are aligned, push the cablehead into the telemetry-section until resistance is met and begin turning the quick-change nut clockwise. As the quick-change nut is drawn down, the "O" rings will slip into the telemetry sub, creating a secure fit. Hand-tighten the nut until secure. These components are illustrated in Figures 12 and 13.

Push the assembled sonde down the length of the V-shaped tool tray into the opening of the KUTh Field Verifier until it stops.

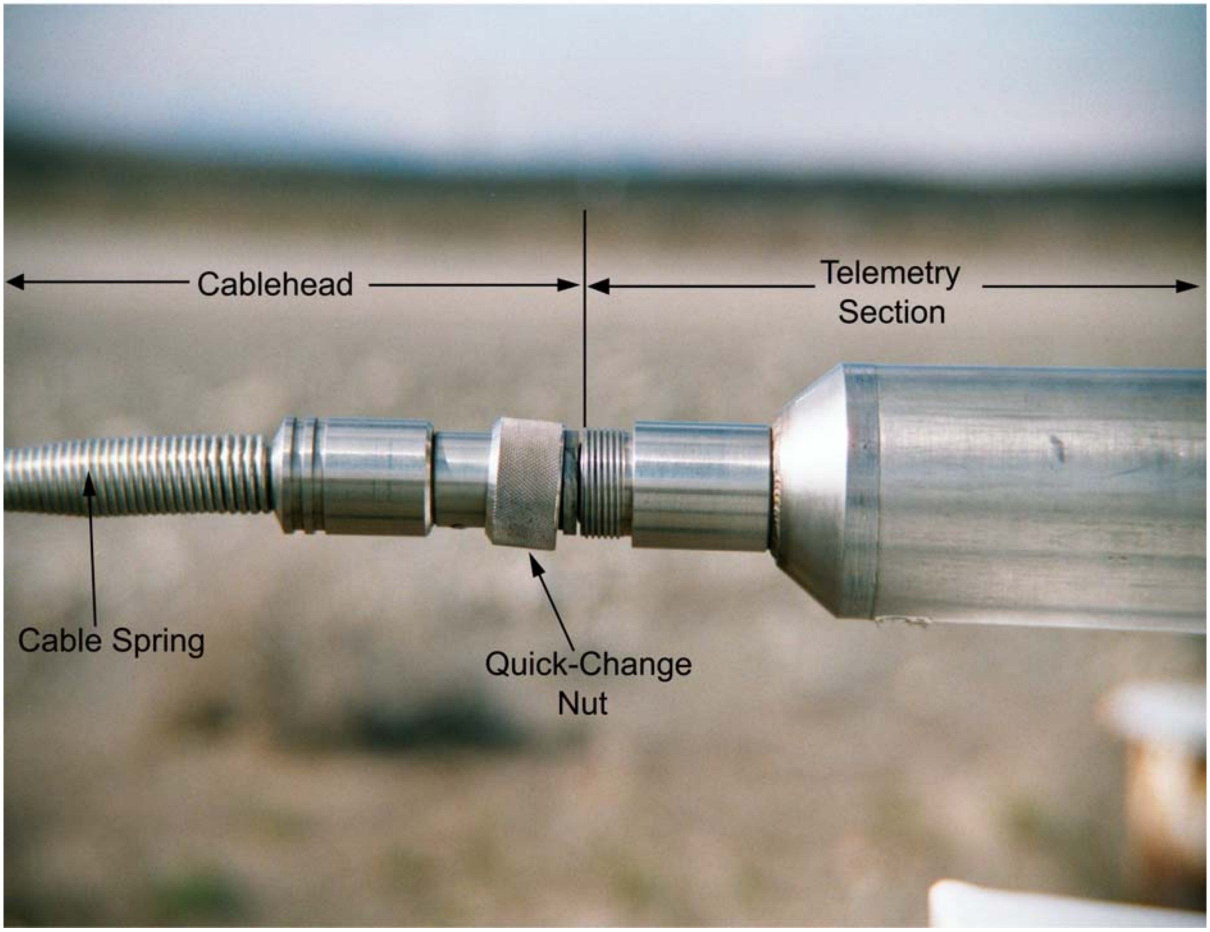

Figure 12. Cablehead/Telemetry Section Connection

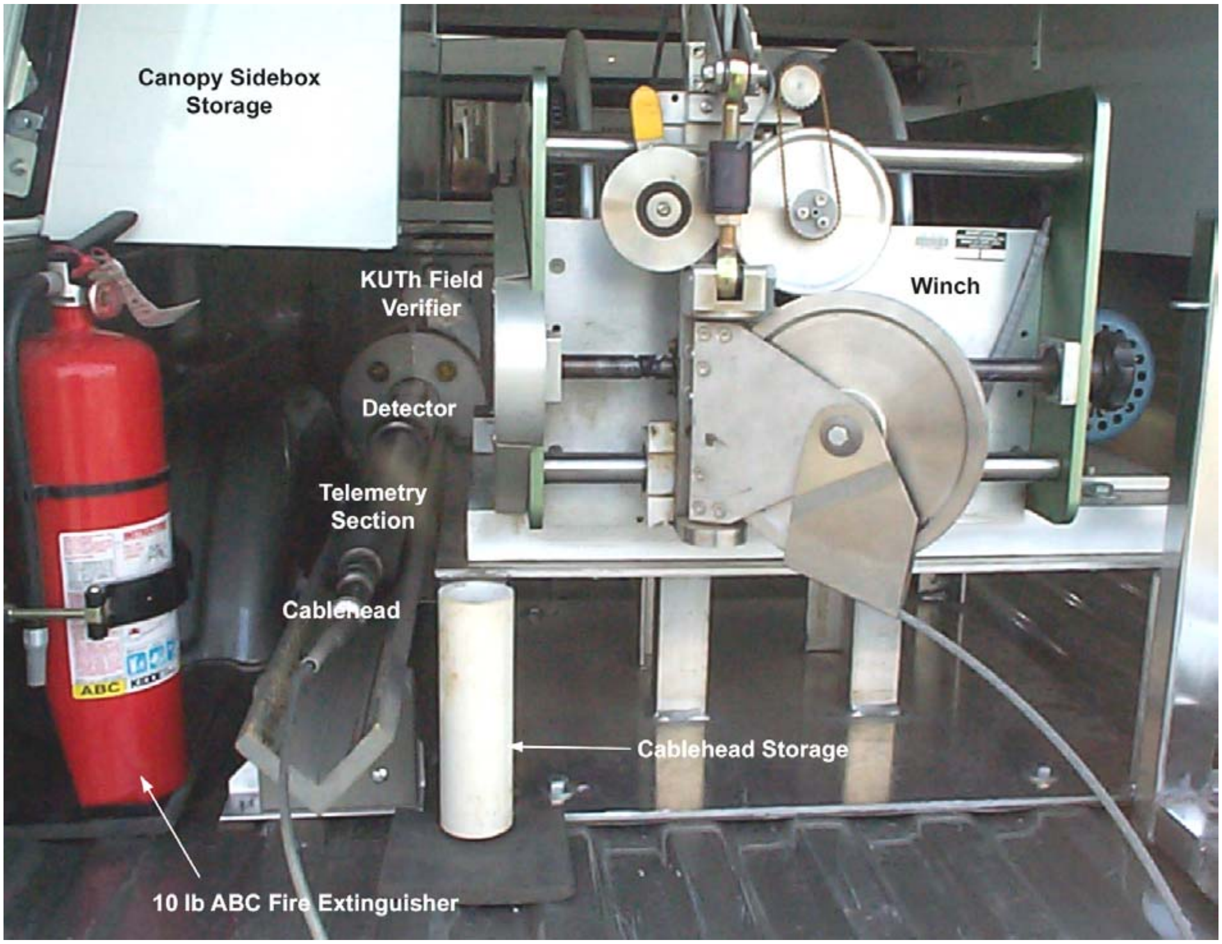

Figure 13. Assembled Sonde in the Tool Tray

5.0 Supplying Power to the Supporting Systems

These instructions describe the power up sequence, partial set-up, and initialization of supporting systems found on the RAS prior to data acquisition. These systems include:

- ProSine inverter
- Mount Sopris winch
- Power distribution strip
- Sonde
- Logging computer

Before proceeding with the procedure, complete Section 3.0, "Vehicle Operations," and Section 4.5, "Connecting the Detector, Telemetry, and Cablehead." A generalized wiring schematic showing the arrangement of the various RAS components is illustrated in Figure 14.

5.1 ProSine Inverter

After the RAS has moved to a borehole to be logged, the 110-Volt AC electrical power must be first turned ON. Note that all other supporting systems used on the RAS depend on their power from the ProSine inverter. A single switch located inside the logging cab turns ON and OFF the power from the ProSine inverter. The switch is a two-way rocker type labeled *Power* on a control panel with a LCD. Power is OFF in the left position and ON in the right position. When the electrical power is ON, the LCD illuminates, showing the condition of the power output. With the motor idling and with no load on the system, the normal LCD readout is about 14.6 Volts and 00 amps. The ProSine inverter control panel is illustrated in Figure 15.

> Note: Ensure the power to the power distribution strip and winch control is OFF prior to turning the ProSine inverter ON.

5.2 Mount Sopris Winch

Prior to turning power ON to the winch, the settings on the winch control panel must be checked to ensure the winch can be <u>safely</u> started. The winch controls are located in the logging cabin in a console between the driver and operator seats. Four switches and a digital *Tension* display control the Mt. Sopris winch. Winch control switches are labeled on the control panel as:

- PWR OFF/ON
- Manual/Computer
- Speed Minimum Maximum
- Up/Down
- Tension Display

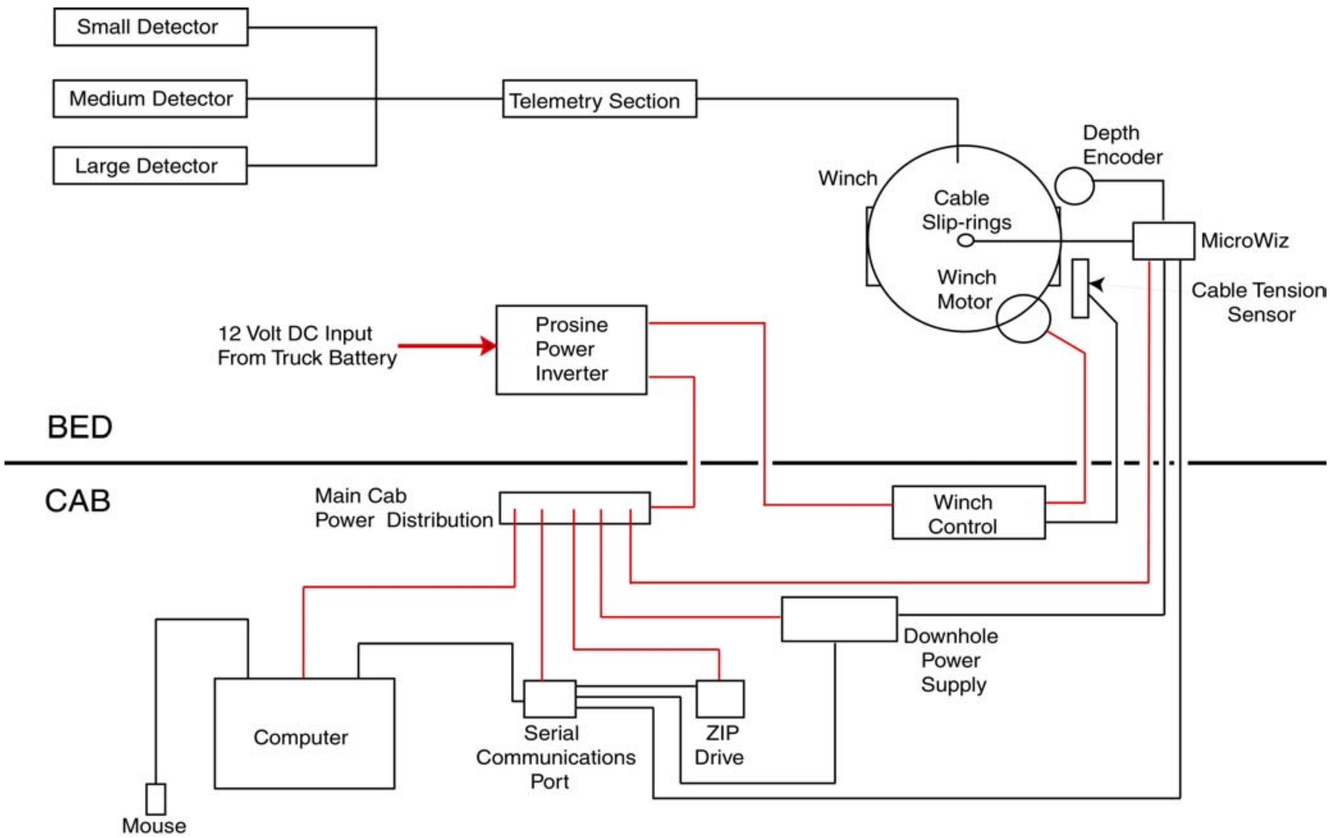

Figure 14. Generalized Wiring Schematic of the RAS Components

Figure 15. ProSine Inverter Control Panel

Set the switches on the winch control panel as follows before turning ON electrical power.

Parameter	Position
Up, Down, or Neutral	Neutral
Minimum or Maximum Speed	Minimum
Manual or Computer	Manual

The main power switch for the Mount Sopris winch is labeled *PWR Off/On* and controls the ON and OFF of electrical power. This switch is located toward the bottom right side on the winch control panel and is turned ON when the switch is depressed. When the winch is ON, the *Tension* display illuminates.

Operating the *PWR Off/On* switch was made more difficult than most push-type switches on purpose. This is a mechanical safety device that is built-in to prevent accidental termination of power to the Mount Sopris winch.

The Mount Sopris control panel and digital *Tension* display is illustrated in Figures 16 and 17.

5.3 Power Distribution Strip

A 110-Volt power distribution strip, with six outlets, is affixed to the back of the logging cab (Figure 18). The power distribution strip supplies electrical power to the PC, sonde, serial communications port, zip drive, and Micro Wiz multifunction counter.

A two-way rocker switch controls power from the power distribution strip. Power is OFF when the switch is flat in the left position and ON when the switch is flat in the right position. When ON, the left side of the rocker switch is a red color and a green light on the power distribution strip illuminates. Turn ON the power strip.

5.4 Sonde Power Supply

Power to the sonde is controlled by a two-way toggle switch located on the sonde power supply (Figure 18). The sonde power supply is in a box on the back of the logging cab. The two-way toggle switch is labeled ON or OFF. Turn the sonde ON. Once power to the sonde is ON, a 30-minute warm-up time is necessary for the electronic circuits to stabilize before data acquisition begins.

5.5 Logging Computer

The logging computer is secured on a platform in the logging cab. If the power up sequence outlined above is not followed, it can affect the computer's boot up. Turn power ON to the logging computer following startup of the supporting components.

Figure 16. Mount Sopris Winch Control

Figure 17. Mount Sopris Winch Cable Tension Display

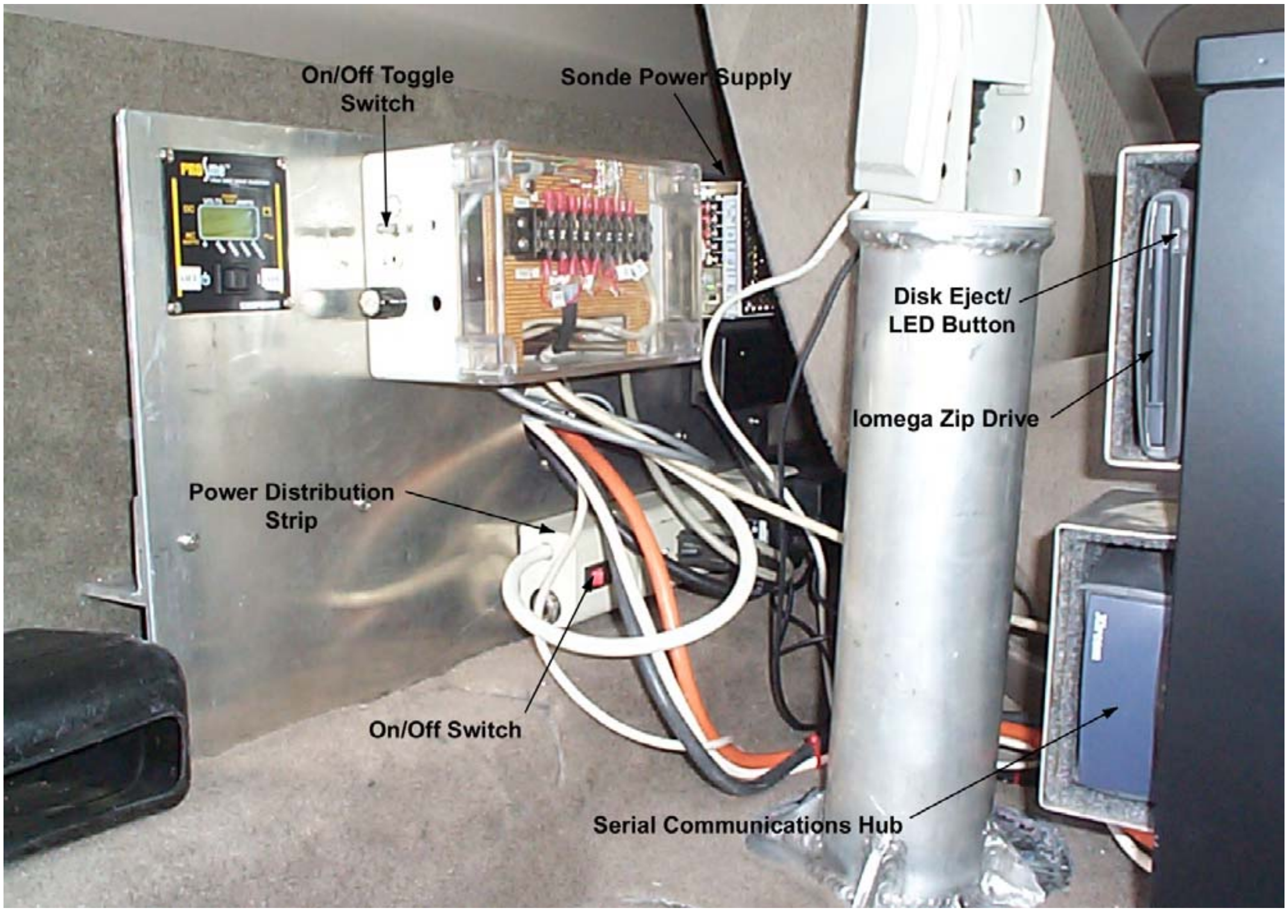

Figure 18. RAS Cab Components

Open the laptop and turn ON the computer by depressing the silver button below the display located just above the PC keyboard. A universal symbol depicting a circle with a vertical slash through it is molded on top of the silver button. Wait as the computer boots up and loads the Microsoft Windows 98 operating system.

6.0 Logging Software and Operation

This section describes the Leak Verification and Monitoring (LVMON) logging software. LVMON is the custom-designed logging software used for all logging and data acquisition activities. It records the logging parameters, displays and stores the data, and controls the data collection.

6.1 Invoking the LVMON Program

This section assumes that the reader is familiar with using a PC, mouse, PC terminology, and manipulating PC software programs. Start in the PC's desktop screen and click on the LVMON icon to invoke the logging program. Wait for the program to boot.

When the LVMON program opens, the first window to open is a banner. The window banner appears across the top of the computer screen and cannot be moved. The window banner represents a control panel, where different menu options can be selected to set up the LVMON program.

Two active viewing boxes appear on the control panel labeled *Depth* and *Speed*. The logging operator uses this widow to view the logging depth and logging speed in real time. A command button, labeled *Preset*, is also present on the control panel and is used to adjust logging depth. This window is illustrated in Figure 19.

Through the control panel, access, set up, and operation of the LVMON program is controlled. These windows are listed along the top of the banner. Using the menu on the control panel, the options include:

- Header
- Pre/Post Verify
- Begin Logging
- Help
- Quit

As long as the LVMON program is running, the window banner will always be open and displayed across the top of the PC's screen.

6.1.1 Depth

Data collection involves knowing the position of the sonde inside the borehole at all times. The RAS is set up to log in units of feet. The active view box labeled *Depth* on the control panel conveys the current logging depth in real time to the logging operator. The operator must monitor the logging *Depth* at all times during data collection for <u>safe</u> operation. Through the computer software, LVMON synchronizes the depth on the control panel with the Micro Wiz multifunction counter.

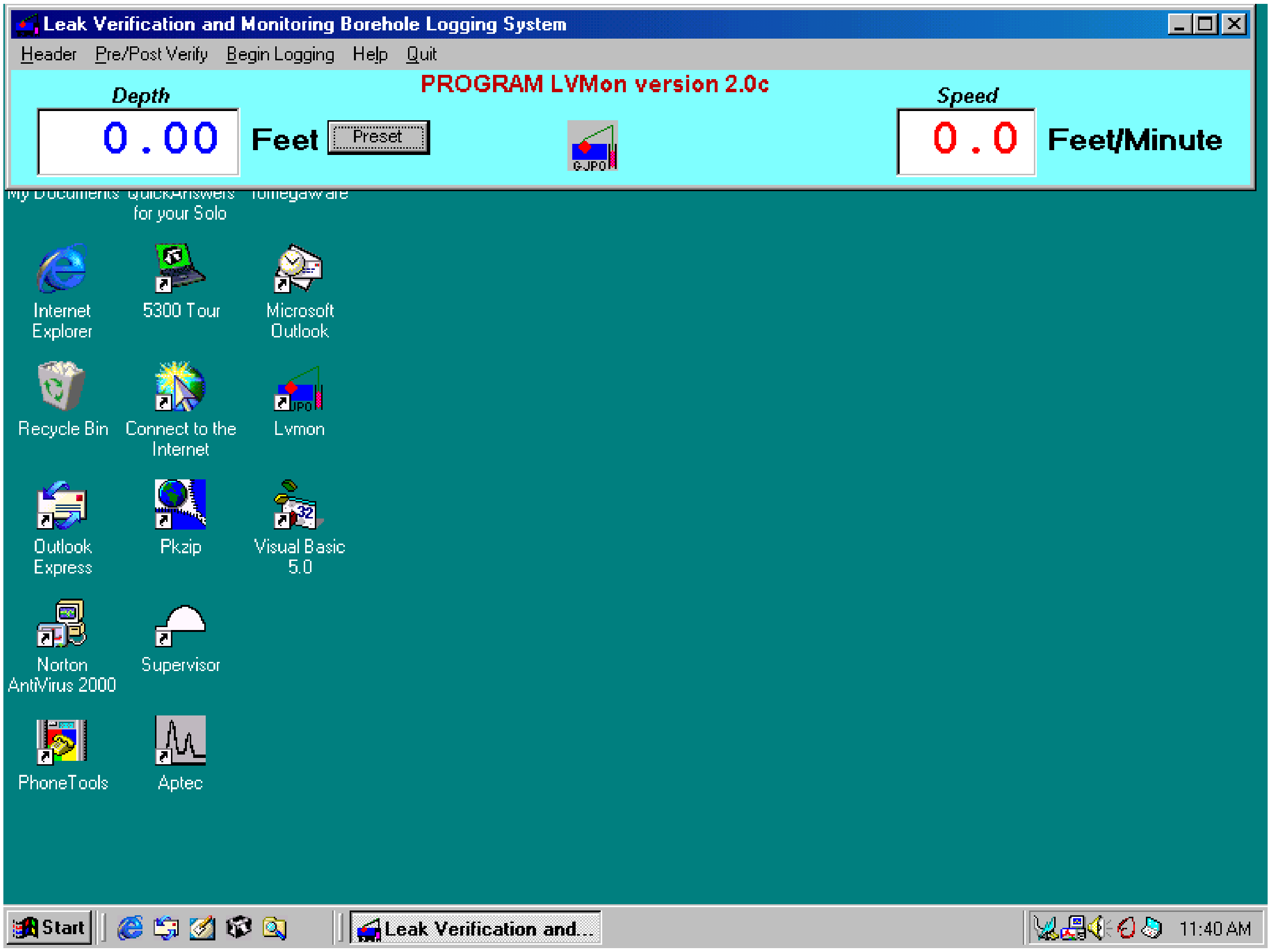

Figure 19. LVMON Logging Program Control Panel Window

6.1.2 Speed

Speed refers to the movement of the sonde in the borehole in feet per minute (ft/min) as data are being acquired or when the tool is being lowered into the borehole to a specific depth. The active view box labeled *Speed* on the control panel conveys to the logging operator how fast the sonde is moving in real time. The operator must monitor the *Speed* of the sonde at all times during data collection for safe operation.

6.1.3 Preset

The command button labeled *Preset* when invoked from the control panel opens a window with the following options:

- Close
- Preset
- Set Zero

The *Preset* window is shown in Figure 20.

6.1.3.1 Close

The command button labeled *Close* is self-explanatory and is used to close the *Preset* window.

6.1.3.2 Preset

In the box labeled *Preset,* the operator enters a value that represents the detector position at the beginning of logging. Values greater than or equal to zero can be used. When a value is entered, LVMON will initiate depth counting from that value. The LVMON program will reset the Micro Wiz multifunction counter to the value set in the preset. This scenario will be discussed in Section 8.3, "Zero Depth Set Up."

The *Preset* function will be utilized when the setup causes the detector zero mark to be below the top surface of the mast base plate. The distance in feet between the tool mark and the base plate surface is entered as a preset value, and depth counting will be initiated from that depth.

6.1.3.3 Set Zero

Before logging begins, a zero depth reference must be established. For most RAS logging, the zero depth is referenced at the top surface of the installed mast base, unless otherwise specified. A scribe mark around the lower outside surface of each of the detector sub housings indicates the zero depth reference for the particular detector. For most RAS logging, the scribe mark is aligned with the top surface of the mast base plate to establish the zero depth reference. After the sonde is moved to the zero depth (following setup), pressing the *Set Zero* button will clear previous values and reset the sonde position as the new zero depth. Press *Close* to close the *Preset* window.

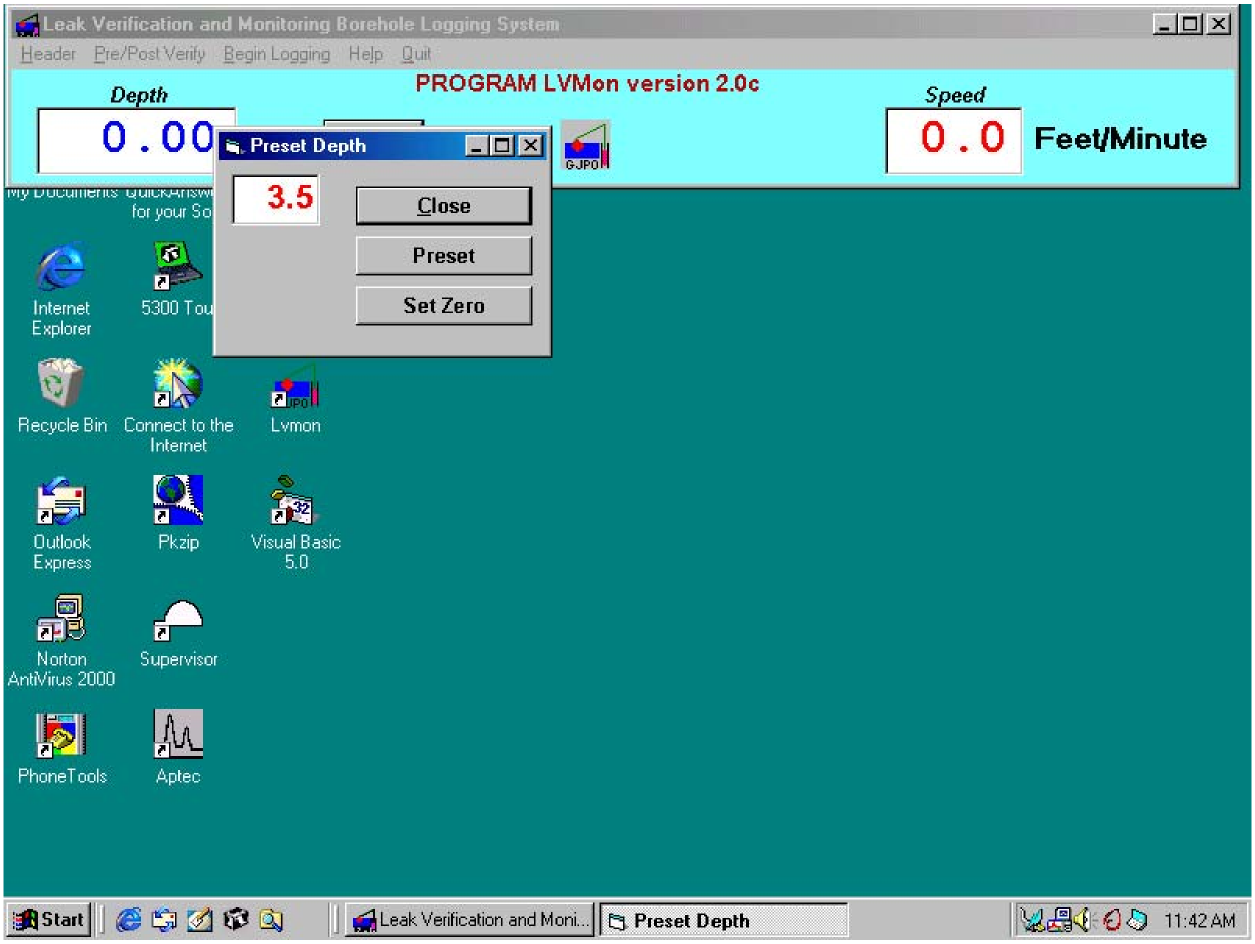

Figure 20. LVMON Logging Program Preset Depth Window

There may be cases in which the mast base plate cannot reach ground surface due to an obstruction such as a plastic cover. Once the tool enters the mast base, the scribed reference mark on the tool housing is not visible. To zero the logging tool with this setup, the distance from ground surface to the top surface of the mast base plate should be measured and recorded. The logging tool can be zero-referenced as in the previous paragraph, lowered into the borehole the measured distance, and re-zeroed by pressing the *Zero* button, ensuring the detector zero reference is aligned with ground surface.

6.2 Header

Header is one of the main data windows used by the LVMON program. Invoke the *Header* window from the LVMON control menu. On the *Header* window, the following information is recorded:

- Borehole Information
- Logging Run Information
- Logging System Information
- Comments

This information will be listed on the borehole monitoring request form (Figure 21) provided to the operator prior to logging.

Three command buttons are used to cancel, save and close, and copy to zip the data entered in the information boxes. These command buttons are labeled as:

- Save + Close
- Cancel
- Copy to Zip

Information entered in the *Header* window is saved to a header data file that is provided with the log data for use during analysis of the log data. This window is illustrated in Figure 22.

6.2.1 Borehole Information

Farm, tank, and borehole number identification (ID) are entered where appropriate in accordance with the borehole monitoring request form. Entries must be 1 to 8 characters in length and can be only alphanumeric characters including an underscore. Files for the borehole being logged will be stored in a subdirectory on the computer named C:\LogData\FarmID\TankID\HoleNo\. A water level depth can be entered if a depth is known. If the borehole was swabbed prior to logging, a radio button can indicate the selection *yes/no/unknown*.

Stoller Grand Junction Office established 1959	Hanford Single Shell Tank Farms **Borehole Monitoring Request**	Request #:
		Hole #:
		Date:

Requested by:	Organization:	Phone#:
Depth interval:	Log Frequency:	Log Event:
Anticipated Contaminants & Levels:		
Comments:		
Special Instructions:		
Data Directory Structure -Tank Farm:	Tank:	Borehole:
Zero Depth Reference:	Logging System:	

			Log Parameters		Interval		Return Error	Gain Adjust			
Date	Det	Filename	Speed	Sample	Top	Bot		Depth	Peak	Log By	Zip #

Notes & Observations:

Data Transfer by	Date	Directory	Notes

Data Analysis by	Date	Directory	Notes

Data Analysis Notes:

White – Original (Stoller) Yellow – Data Transfer Receipt (Stoller) Pink – RAS Operator Receipt (HSC)

Figure 21. Borehole Monitoring Request Form

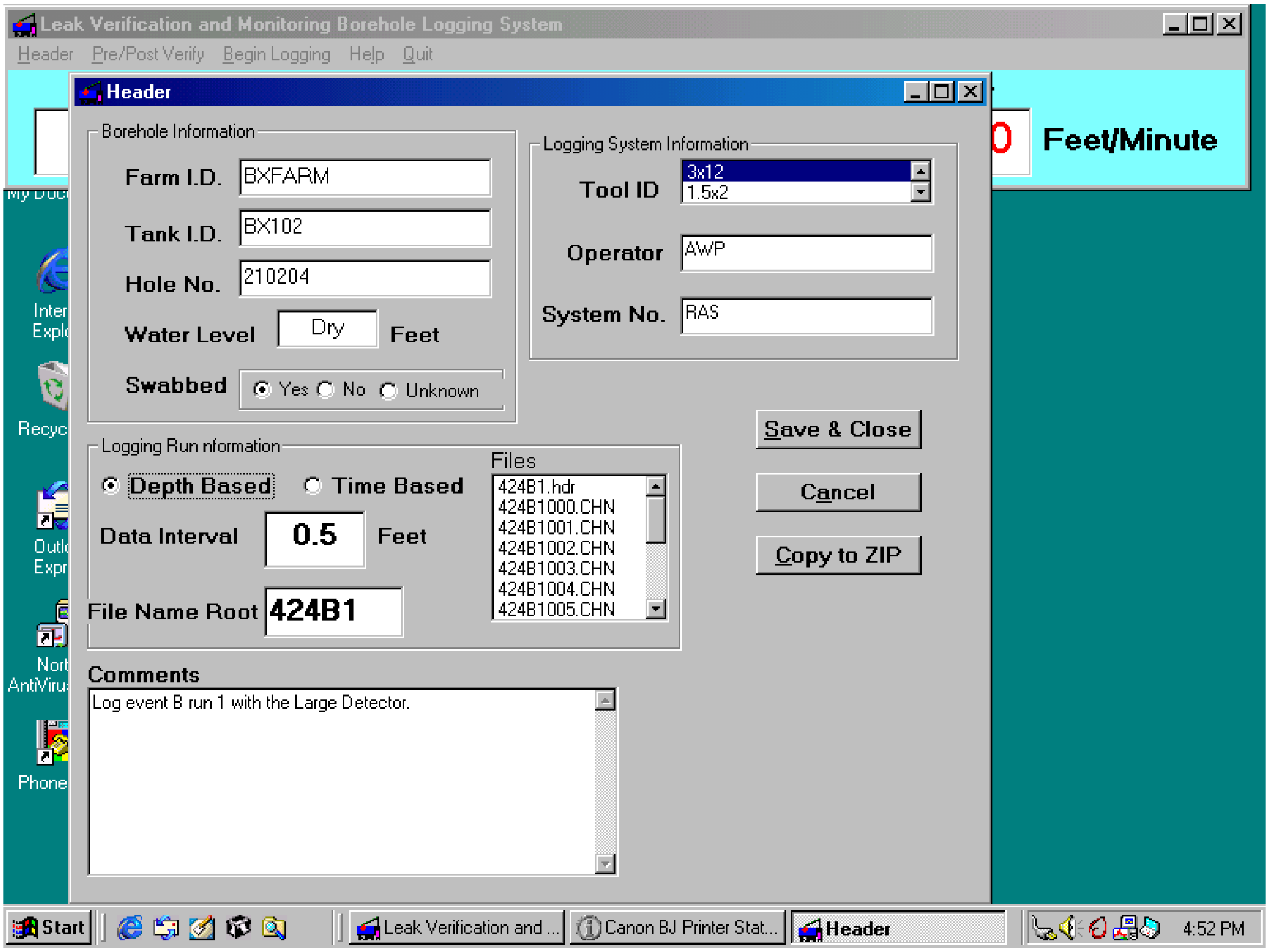

Figure 22. LVMON Logging Program Header Window

6.2.2 Logging Run Information

In this information box, indicate if the logging mode is *depth based* or *time based* in accordance with the borehole monitoring request form. In most instances, RAS data acquisition will be *depth based* logging using 0.5-ft sample intervals. Selecting the appropriate radio button marks this selection.

Input a *data interval* and *file root name* in accordance with the borehole monitoring request form. The *file root name* must be 5 characters long. If a second log run is made in the same borehole, the *file root name* must be changed to reflect the new log run and saved. When saved, a new header data file will be made. If the root name is not changed, the LVMON program will overwrite the spectral files collected during the previous survey. Before beginning a new survey, all files should be copied to a zip disk using the *Copy to Zip* button.

6.2.3 Logging System Information

In this information box, select the logging *Tool ID*, enter an *Operator* name or initials, and the *System Number*. The *Tool ID* refers to the detector being used for the current log run and is indicated by selecting the dimension of the detector's crystal. Crystal size as it relates to the detectors was described in Section 2.3. The *System Number* for this procedure will be noted as the RAS 1.0.

6.2.4 Comments

Three basic entries should be recorded in the comments section including:

- Logging date
- Depth interval
- Log run number

Other comments should be made that convey observations of new or missing information that would be important for the analyst to know but can only be observed by personnel in the field. Examples would include details regarding an encountered borehole obstruction, a change in water level or the presence of water, casing stick-up, or other zero reference details that may affect logging results.

6.2.5 Save + Close

Header information is saved to the PC's hard drive by clicking on the *Save + Close* command button, which also closes the *Header* window. Once *Save + Close* is initiated, a header file is automatically created and saved in the C:\LogData\FarmID\TankID\HoleNo\ as a <*file root name*>*.HDR* file and the *Header* window closes.

6.2.6 Cancel

Selecting the *Cancel* command button on the *Header* screen aborts any saving of the header data. Borehole and log run information that was entered would be lost and not saved. All information would have to be reentered.

6.2.7 Copy to Zip

The *Copy to Zip* is a command used to copy the spectral data and header file to the zip drive. Using the *Copy to Zip* command will invoke LVMON to automatically copy the data files from the current working directory on the PC's hard drive to a zip disk. The LVMON program will prompt the user to acknowledge that it is correct to set up the appropriate directory structure on the zip disk prior to copying files. Data are copied at the end of each log run, and the zip disk is given to the Stoller point of contact at the end of the workday.

6.3 Pre/Post Verify

Pre/Post Verify is one of the main data windows used by the LVMON program. Invoke the *Pre/Post Verify* window from the LVMON control menu.

Prior to data acquisition each day, the RAS logging system must be checked to verify that it is operating correctly and within established performance parameters, which is achieved by conducting a pre-survey verification in the KUTh Field Verifier.

Prior to logging a borehole, the gain must be set to adjust for magnetic effects inside the carbon steel casing. The pre-survey gain adjustments are performed inside the borehole at depths specified on the borehole monitoring request form. The borehole monitoring request form will also list which radioisotope will be used to make the gain adjustments.

A post-survey gain check will be performed after completing a log run in a borehole. This will be performed at the same depth as the pre-survey gain adjustment.

Eight command buttons, three input windows, and two radio buttons are listed on the left side of the *Pre/Post Verify* window. A *Gain Slider* separates the text and graph areas. Each of their functions are described below in the order they are appear on the window except *Gain*, which is explained last. This window is illustrated in Figure 23.

6.3.1 Save Cal File

Depending upon which *Pre Verify* or *Post Verify* radio button was chosen (Section 6.3.8), when the *Save Cal File* command is executed, the verification survey will be saved to the PC's hard drive. The saved file will be named xxxxxCA<u>B</u> if it is a “Pre” or <u>b</u>efore survey verification and xxxxxCA<u>A</u> if it is “Post” or <u>a</u>fter survey verification, where xxxxx is the *File Root Name*.

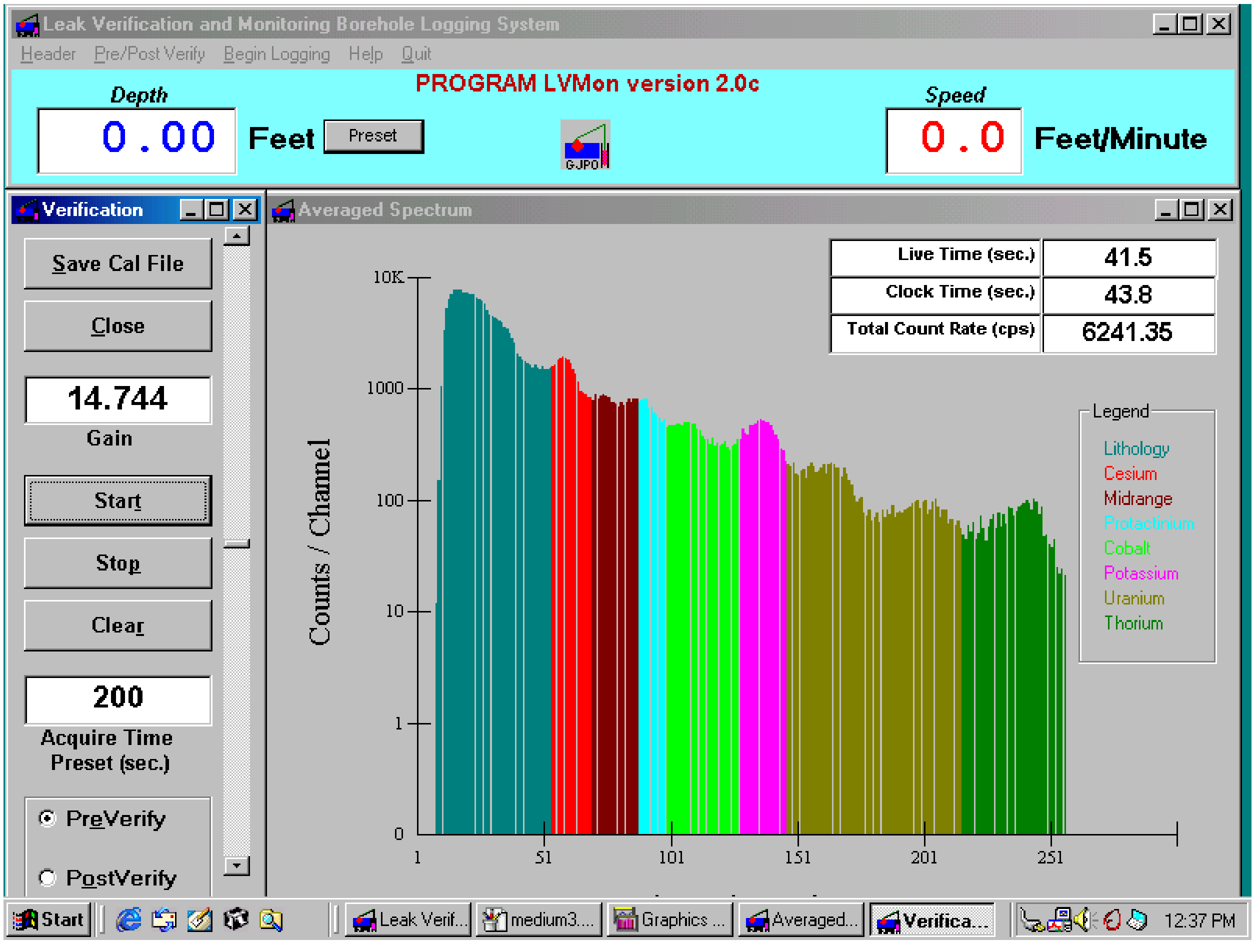

Figure 23. LVMON Logging Program Pre-/Post-Verify Window

6.3.2 Close

Depressing the *Close* button will close the *Pre/Post Verify* window. Choosing *Close* before using the *Save Cal File* command will abort the verification. A pre/post verification file will not be created and any verification spectra will be lost.

6.3.3 Start

Depressing the *Start* button will collect a *Pre/Post Verify* spectrum for the specified *Acquire Time* (Section 6.3.6). LVMON launches a graph on the verification screen displaying the spectrum being collected. When the *Acquired Time* is reached, the program automatically stops collecting data and waits for the next input command.

6.3.4 Stop

Depressing the *Stop* button will end the data acquisition and suspend further action until either the *Start* or *Clear* command is given.

6.3.5 Clear

Depressing the *Clear* button will clear the spectral data displayed so that a new data can be acquired.

6.3.6 Acquire Time, Preset (sec.)

Values in units of seconds are entered in the *Acquire Time* box. For RAS logging, the following acquisition times will be used for each of the three detectors when performing *Pre-Survey Verification, Pre-Survey Gain Adjustment, and Post-Survey Gain Check* spectra:

Small detector	1000 sec live time
Medium detector	600 sec live time
Large detector	200 sec live time

Using the PC's keyboard, type in a value.

6.3.7 Pre Verify, Post Verify

Mark the appropriate radio button depending upon which verification spectra are being collected. Pre means "before" a log run is initiated and is used when collecting a *Pre-Survey Verification Spectrum* or a *Pre-Survey Gain Adjustment Spectrum*. Post means "after" a log run is complete and is used when collecting a *Post-Survey Gain Check Spectrum.*

6.3.8 Gain

Gain adjustment is crucial to data comparability between log runs. Shifts in gain result in displacement of peaks in the spectra, which affect the window count rates. The gain will be adjusted during the pre-survey verification each morning and prior to each log run inside the borehole. It is necessary to adjust gain prior to each logging run, and to monitor gain during the run. The *Pre-Survey Gain Adjustment Spectrum* is collected inside the borehole to adjust for magnetic effects that may be caused by the carbon steel casing. A *Post-Survey Gain Check Spectrum* will be collected after each log run at the same location as the pre-survey gain adjustment. The depth and radioisotope that will be used for the pre-survey gain adjustment and post-survey gain check for an individual borehole will be listed on the borehole monitoring request form.

Gain adjustment is accomplished by collecting a spectrum with the detector in the field verifier (for the pre-survey verification) and by collecting a spectrum in the borehole at the given depth (for the pre-survey gain adjustment). The *Pre/Post Verify* window allows operator entry of gain values. These values are adjusted to center the 1460.8-keV gamma peak associated with ^{40}K within the potassium window. Other radioisotopes such as ^{137}Cs may also be used for the pre-survey gain adjustment. Typical gain values are listed in the following table. These values represent starting points. The actual values used may differ, because the point of gain adjustment is to align a specific peak within a spectral window.

Sonde	Value
Small	11.000
Medium	10.000
Large	18.000

Gain drift is a characteristic of the system, and must be monitored during logging operations. Gain drift is expressed as a shift in the energy level of a specific peak over time. Specific criteria for evaluation of gain drift will be established as operational experience is gained with the RAS.

Gain adjustment cannot be made during logging. If gain drift becomes excessive, it will be necessary to suspend logging operations, move the detector to the gain adjustment depth and re-adjust the gain. When logging is resumed, there should be an overlap of at least 1 ft to ensure data continuity.

In the *Pre/Post Verify* window, *Gain* values can be entered directly by using the PC keyboard, or manipulated by the mouse using the *Gain Slider* located between the input and graph areas. The gain must not be adjusted while the system is actively acquiring spectral data. Making adjustments during data acquisition may cause a communication error requiring the operator to reboot the program.

6.3.8.1 Making Gain Adjustments

Choose an *Acquire Time* for the particular detector in accordance with procedures and enter it into the acquire time window. Click *Start* to observe the accumulation of a spectrum. Allow enough counts to accumulate to observe the potassium-40 (^{40}K) peak in the spectrum. The ^{40}K peak should fall within its highlighted window in the spectrum. The cesium-137 peak may be used during the pre-survey gain adjustment if noted on the borehole monitoring request form. If the peak is not in the correct location, stop acquisition with the *Stop* button, adjust the *Gain Slider* a small amount up or down, and click the *Clear* button. Click *Start* to restart acquisition. Repeat this process until gain is adjusted appropriately and the peaks appear centered within their highlighted windows. Once a satisfactory gain value has been determined, clear the data field and start acquisition for the prescribed acquisition time. Do not make any further gain adjustments when the verification spectra are being collected. The spectrum shows the live time as it accumulates. When the live time reaches the preset acquisition time, acquisition of the spectrum will halt. Press *Save Cal File* to save the verification spectrum. Figures 24, 25, and 26 show the pre/post verify windows for the small, medium, and large detectors, respectively. These windows show the position of the ^{40}K peak in the windows for each of the detectors, as well as the gain value used during the acquisition.

6.4 Begin Logging

Prior to the initialization of logging, the zero depth reference must be established as described in Section 6.1.3.3, “Set Zero,” and in Section 8.2, “Zero Depth Set Up.”

Begin Logging is the main command used by the LVMON program to initiate data acquisition. Invoke the *Begin Logging* command from the LVMON control menu.

Begin Logging is used only after the sonde is set at the log run start depth and data collection is ready to begin. Once invoked, LVMON starts collecting spectral data using the set up parameters input on the *Header* and *Pre/Post Verify* files. LVMON launches a graph window that shows the spectra being collected in addition to the window banner displaying the *Depth* and *Speed*.

Data files are stored as <*File Root Name*>.CHN files in subdirectories as described in Section 6.2.5.1, “Save + Close.”

6.5 Help

The *Help* command from the LMVON control panel is disabled.

6.6 Quit

Invoking the *Quit* command from the LVMON control panel closes the LVMON program.

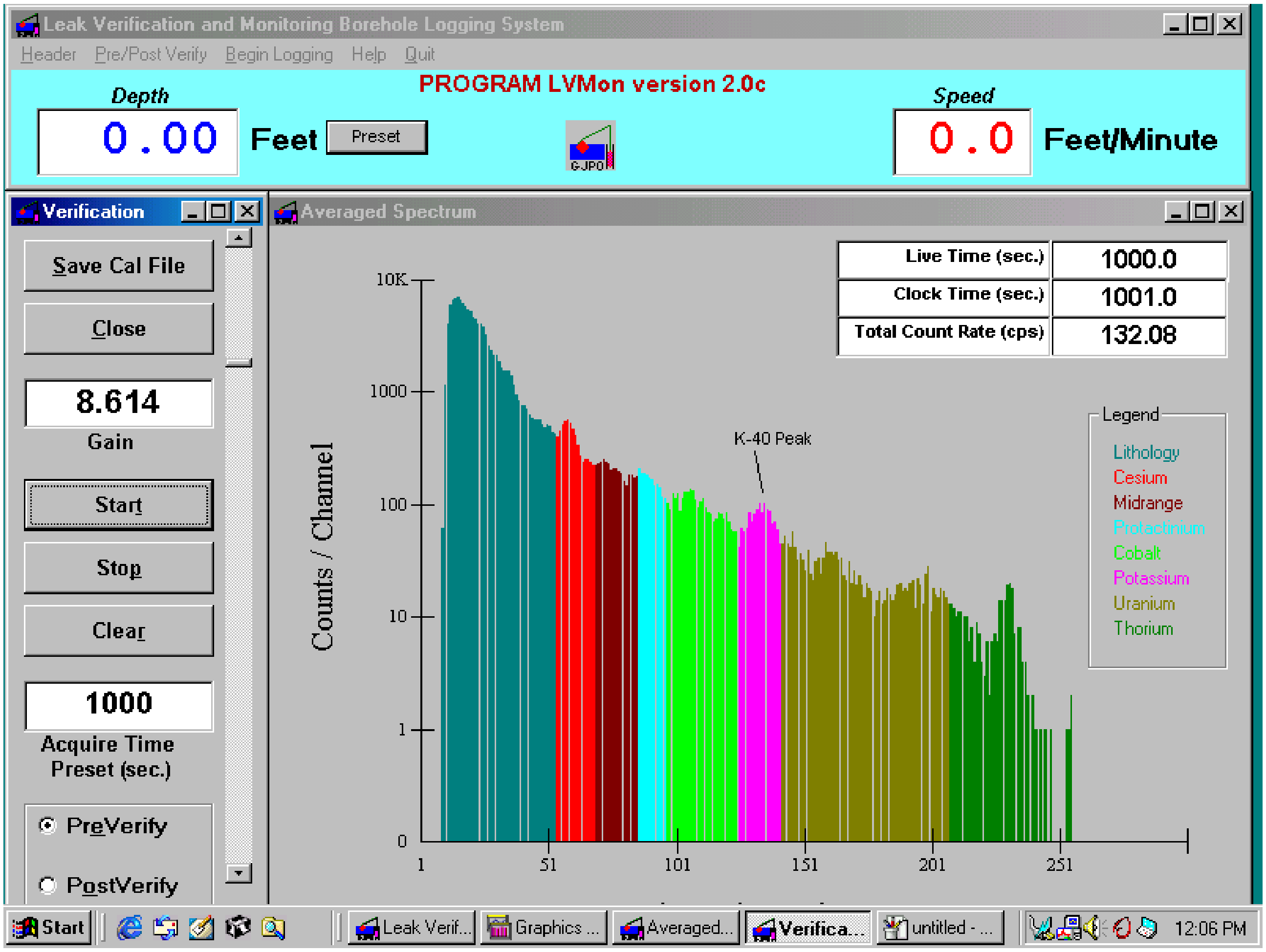

Figure 24. LVMON Logging Program Pre-/Post-Verify Window for the Small Detector

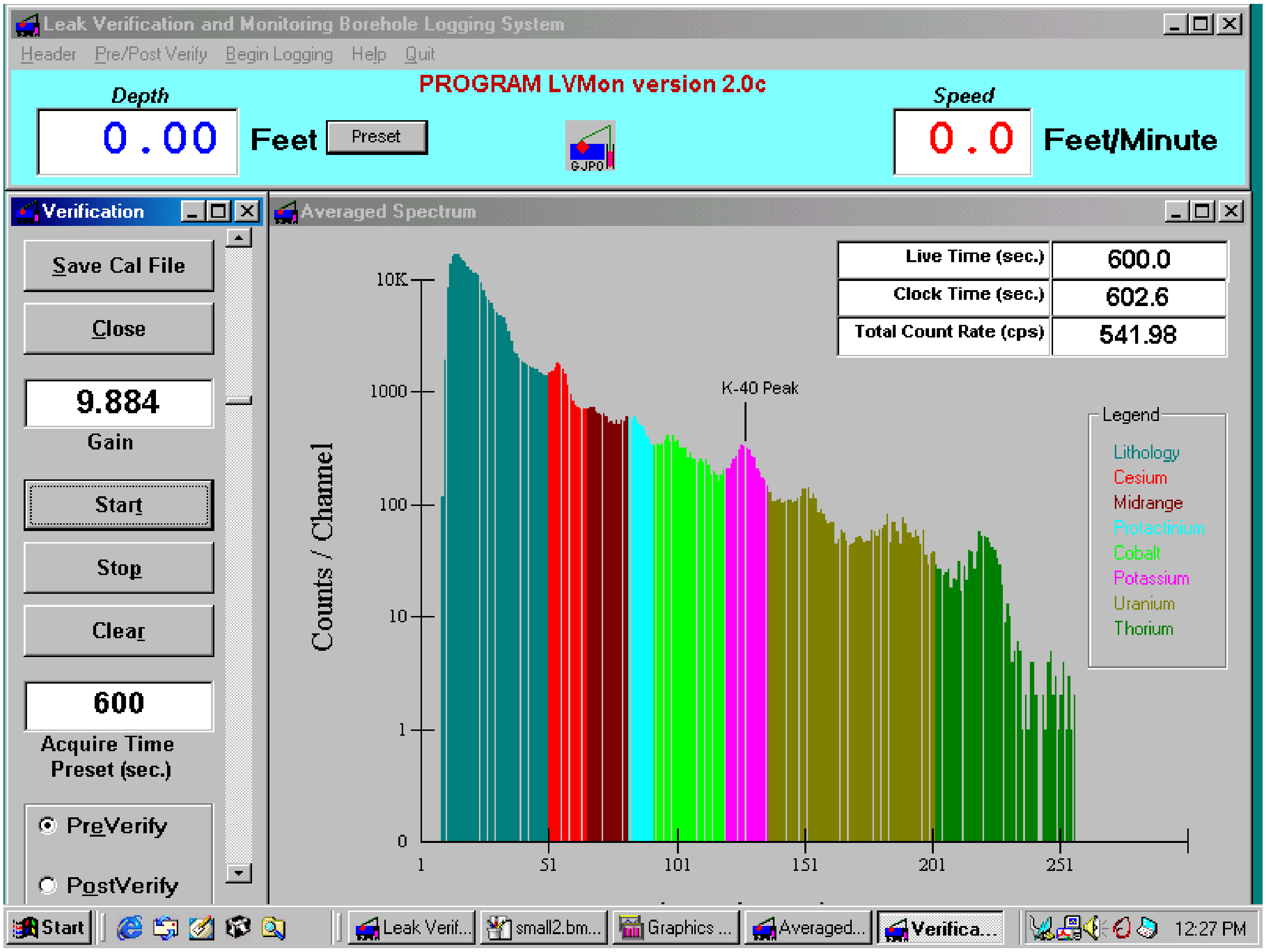

Figure 25. LVMON Logging Program Pre-/Post-Verify Window for the Medium Detector

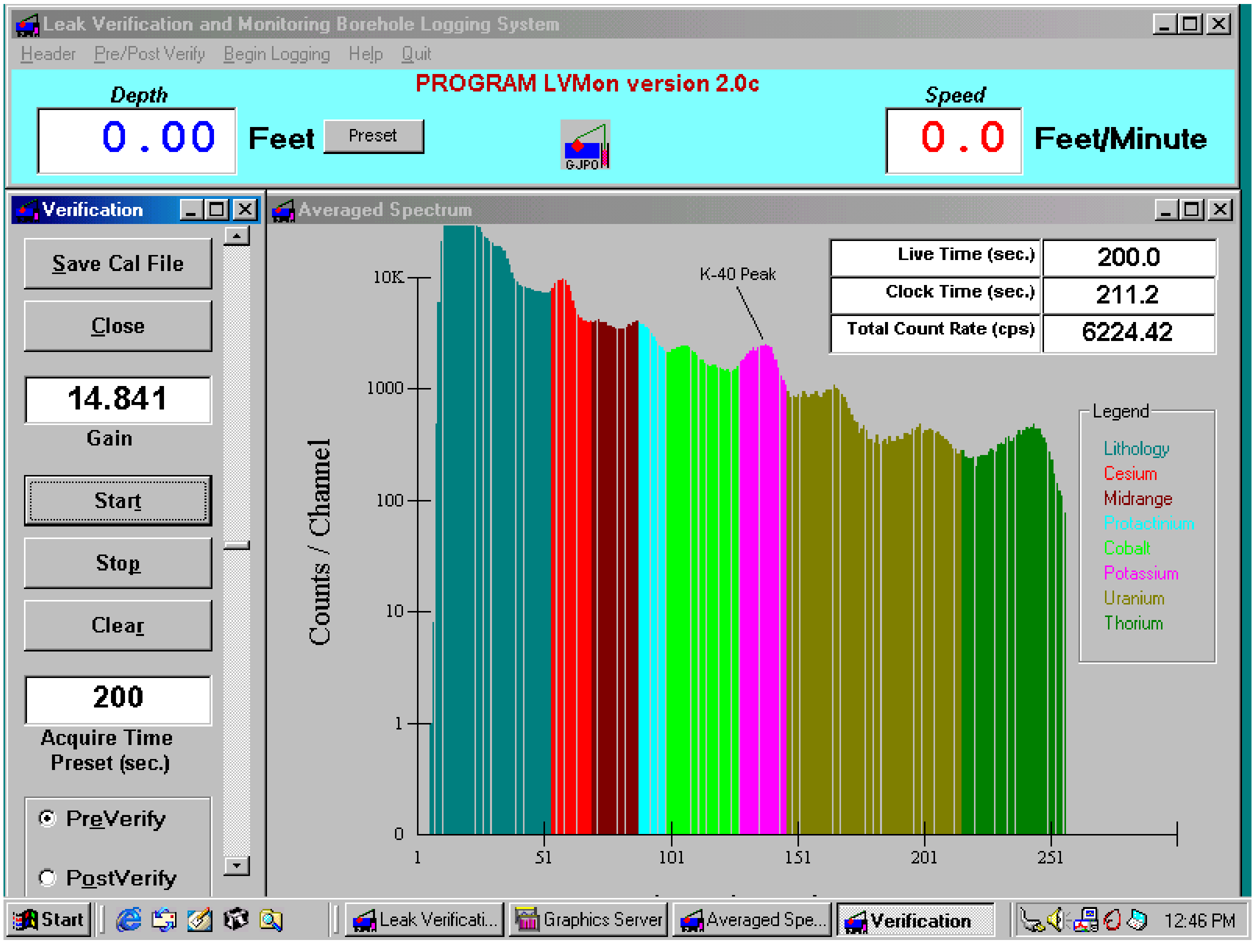

Figure 26. LVMON Logging Program Pre-/Post-Verify Window for the Large Detector

7.0 Mount Sopris Winch Operation

7.1 Mount Sopris Winch

An electrical winch manufactured by Mount Sopris controls the movement of the logging tool in the borehole. The winch control is located in the logging cab and controls the direction of the sonde up or down and speed in units of feet per second (ft/min). Components of the Mount Sopris winch include:

- Cable tension sensor
- Electric motor
- Level wind adjustment
- Sheave wheel
- Depth encoder

These components are illustrated in Figure 27.

7.2 Winch Control Panel Description

The winch controls are located in the logging cab on a panel and are used by the logging operator to control the depth of the sonde and the cable spooling rate. The winch control panel consists of the following toggles and switches to control its operation:

- Power ON/OFF
- Mode Computer/Manual
- Direction Up/Down
- Speed Adjustment Minimum/Maximum
- Digital Tension Display

A digital display on the winch control panel shows the cable *Tension* during logging in units of pounds (lbs) (see Figures 16 and 17).

7.2.1 Power ON/OFF

The main power switch for the Mount Sopris winch is labeled *PWR Off/On* and controls the ON and OFF of electrical power. This switch is located toward the bottom right side on the winch control panel and is turned ON when the switch is depressed. When the winch is ON, the *Tension* display illuminates.

The *PWR Off/On* switch was made more difficult than most push-type switches on purpose. This is a mechanical <u>safety</u> device that is built-in to prevent accidental termination of electrical power to the Mount Sopris winch.

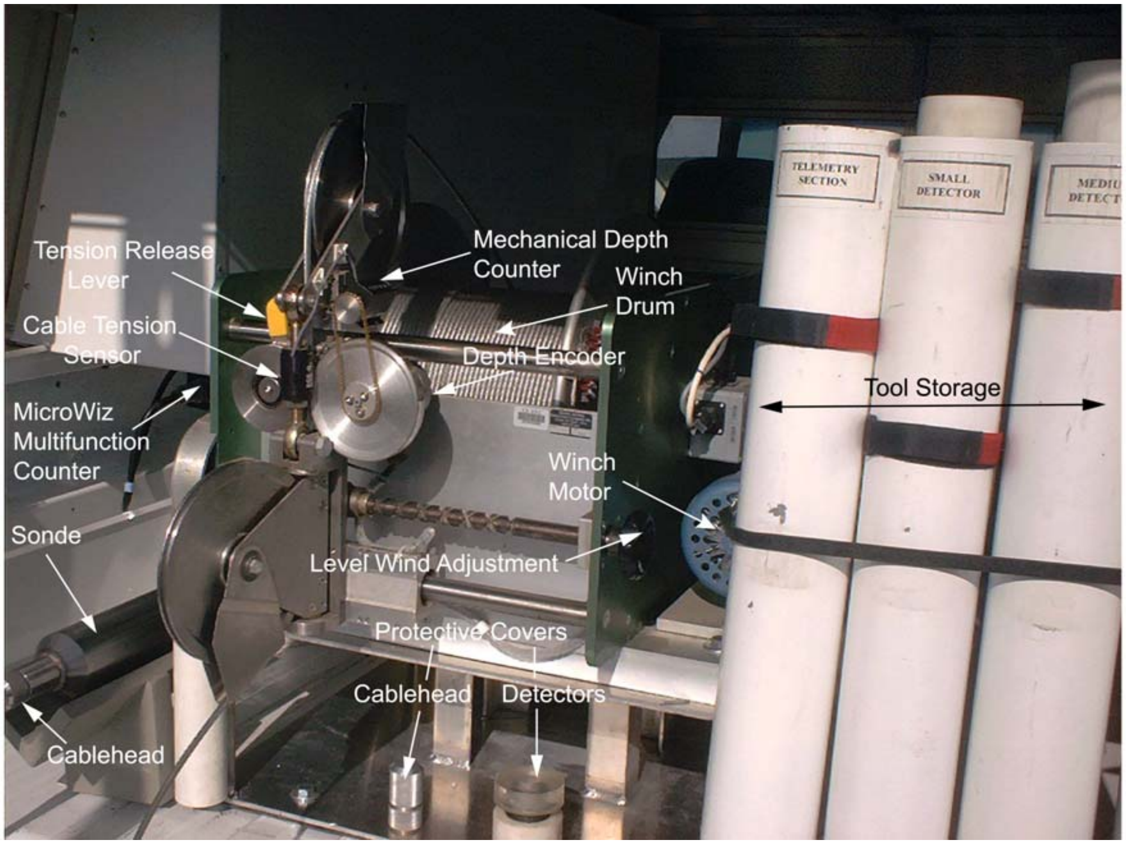

Figure 27. RAS Rear View Showing the Major Components of the Mount Sopris Winch

7.2.2 Manual/Computer

A three-way toggle switch labeled *Manual/Computer* controls the operating mode of the winch. The function of each toggle position is described below.

1) *Manual* mode is toggle position *Up* and allows the logging operator to manually control the winch using the *Up/Down* and *Speed* controls. Currently, the RAS is set up to operate in the *Manual* mode only.

2) *Computer* mode is toggle position *Down* and allows the operator to control the winch using the LVMON program. In computer mode, the winch direction and speed are both under PC control. Currently, this operating mode is disabled in the LVMON program.

3) *Neutral* mode is toggle position *Center*, which suspends the winch control in a non-functioning setting. This is a <u>safety</u> position when the winch is not being used but is ON. In the *Neutral* mode, the *Up/Down* and *Speed* controls are disabled.

7.2.3 Up/Down

A three-way toggle switch labeled *Up/Down* controls the up or down direction of the logging tool. The function of each toggle position is described below.

1) Toggle position *Up* directs the winch to move in the upward direction.

2) Toggle position *Down* directs the winch to move in the downward direction.

3) Toggle position *Neutral* suspends the winch in a non-functioning setting. This is a <u>safety</u> position when the winch is ON. In the *Neutral* position, the *Up/Down* and *Speed* adjustment controls are disabled.

7.2.4 Speed Minimum/Maximum

A rotating knob labeled *Speed Min Max* controls the speed adjustment in units of feet per minute (ft/min). The *Speed* adjustment is used to move to and from different logging depths and control the rate of movement. The operator adjusts the *Speed* manually during data acquisition at a specified rate in accordance to the prescribed log run parameters. During most RAS logging, the data are collected at an acquisition rate of 1.0 ft/min.

- The *Speed Adjustment* knob at the *Minimum* position moves the winch at zero ft/min. This is a safety position when the winch is ON. In the *Minimum* position, the winch won't move.

- The *Speed Adjustment* knob at the *Maximum* position moves the winch at a rate of about 25 ft/min.

Note: For safety, the *Speed Adjustment* should always be set at the *Minimum* position when the winch is ON but is not being used.

7.2.5 Digital Tension Display

A digital *Tension* display, manufactured by DIGITEC, is located on the left side of the winch control panel. The display is a safety device that relays what tension is being exerted on the winch by the logging cable and sonde in real time. The *Tension* display is in units of pounds.

7.2.5.1 Digital Tension Display Alarms

The *Tension* display can be preset to alarm, which shuts OFF the winch motor automatically. Knowing which alarm is being displayed is an important safety feature of the digital display. Three weight conditions can exist during logging operations:

1) Normal
2) Low Weight
3) High Weight

The logging operator recognizes an alarm condition when the *Tension* display flashes a warning. Two warnings are possible: a low weight condition will flash LO LO, and a high weight condition will flash HI HI. If an alarm condition exists, the logging operator must clear the alarm by adding more or less weight to the logging cable or logging tool.

The *Tension* display is programmed to alarm below 12 lbs (low weight) and above 130 lbs (over weight). Between weights of 12 and 130 lbs, the settings on winch control panel controls the winch and no alarms will be activated.

The maximum tension parameter is set to sense an over weight condition during borehole logging. If a snag or bind is encountered during normal logging operations, the maximum tension setting could be exceeded, which would turn OFF the winch motor. To remove an over weight condition, the operator must reduce the cable tension and clear the obstruction to override the alarm.

The winch will also be stopped when the cablehead spring encounters the guide/stop device at the top of the mast. This stop is designed as a safety device to prevent spooling of the cablehead into the upper sheave wheel. It is not intended to be a routine stopping mechanism during logging. The operator will stop logging manually with the winch controls when the logging sonde reaches the zero reference position at the top of the borehole.

7.2.5.2 Operating the Low-Tension Winch

The low-tension alarm is a feature built-in by Mount Sopris to assist the operator in spooling cable from the winch. With the low-tension alarm set at 12 lbs, 12 or more pounds have to be applied to the winch cable to move the winch. With the winch ON, configure the winch control panel as shown to remove logging cable:

Toggle Switches	**Conditions**
Power	ON
Mode	Manual
Speed Adjustment	Set above minimum
Direction	*Down*

When the operator grabs the cable and applies 12 lbs or more pounds of tension, the winch starts and allows cable to spool from the drum. When enough length of cable is removed, the cable is released and the winch automatically stops.

By setting the direction switch to the *Up* position and applying 12 or more pounds of cable tension, the winch direction is reversed, allowing cable to be spooled onto the winch drum. With the winch ON, configure the winch control panel as shown to spool cable back ON the winch:

Toggle Switches	**Conditions**
Power	ON
Mode	Manual
Speed Adjustment	Set above minimum
Direction	*Up*

7.2.5.3 Tension Display Programming

A listing for alarm settings and the procedures for programming the DIGITEC display are provided in Appendix B. If additional information is required, it can be found in the DIGITEC manual in the RAS system documentation.

7.3 Micro Wiz Multifunction Counter

In addition to the *Depth* readout found in the LVMON program, there is a second electrical device that indicates depth during data acquisition. A digital multifunction counter manufactured by Micro Wiz is mounted in the back of the RAS bed and is arranged to face the logging operator. This counter is interfaced with the PC and the Mount Sopris winch. Power to the depth encoder occurs when electrical power to the power distribution strip is turned ON. The Micro Wiz multifunction counter is shown in Figure 7. The setup codes and procedures for programming the Micro Wiz multifunction counter are provided in Appendix D.
The operator should watch this readout when moving the logging tool to the desired depth. This readout is updated in real time while the depth readout displayed on the computer is refreshed at a slower rate.

8.0 Logging Initialization

Logging initialization covers the necessary steps to begin data acquisition in boreholes using the RAS. This section assumes that the RAS is set up at a borehole, the correct sonde is attached and inserted in the KUTh Field Verifier, the supporting systems are ON, the PC and LVMON program is booted, and the *Header* data file was completed and saved.

8.1 Verification Measurements

Field verifications are a component in the logging program quality controls and serve as frequent confirmations of the logging system efficiency. Verification measurements are conducted from the *Pre/Post Verify* command screen in the LVMON program. Spectra are collected using the *Gain, Start*, and *Acquire Time* command buttons.

Pre-survey verification spectra will be collected at the beginning of each day and if detectors are switched during the day. The prescribed time interval for the particular detector is given in Section 6.3.6, "Acquire Time, Preset (sec.)."

A separate header file will have to be created each time a pre-survey verification file is collected. The following table lists the information required to create the pre-survey verification file header.

Screen Field	Data Entry
Farm I.D.	RAS10
Tank I.D.	VERIF
Hole No.	LARGE (if using the large detector) MEDIUM (if using the medium detector) SMALL (if using the small detector)
Water Level	NA
Swabbed	No
Tool I.D.	Highlight appropriate tool
Operator	Enter name or initials
System No.	RAS1.0
Depth Based	Select Button
Data Interval	0.5 ft
File Root Name	Enter the date as: YMMDD (where Y represents the last digit of the current year, MM represents the month, and DD represents the day)
Comments	Enter a description of where the vehicle is located

Set up Pre/Post Verifications as described in Section 6.3, "Pre/Post Verify." Slide the sonde in the KUTh Field Verifier and begin collecting a spectrum paying close attention the *Gain* adjustment outlined in Section 6.3.8.1.

8.1.1 Acceptance Criteria

The acceptance criteria for the RAS logging tools are specified in the current RAS calibration report (DOE 2001).

8.2 Mast Assembly and Set Up

The mast assembly is a repetitive operation that requires assembly and disassembly before and after every borehole move. Prior to assembly, inspect the components for wear-and-tear and damage. Report any problems to the Stoller point of contact.

The mast fits over the borehole and supports the logging sonde and cable. The mast is fabricated from aluminum and consists of five components:

1) Mast base with 6-in.-diameter casing adapter
2) Mast
3) 8-in.-diameter casing adapter
4) Mast base with 4-in.-diameter casing adapter
5) Borehole plug

A single sheave wheel is attached to the mast base and mast pole to align the logging cable with the truck winch and borehole. These components are illustrated in Figure 5.

8.2.1 Mast Set Up

The mast bases have been designed to slip inside 4- and 6-in.-diameter borehole casings. After the mast base has been inserted into the casing, the mast is set on the mast base and locked into place with the quick-disconnect pin. The mast assembly is rotated to align the sheave wheels with the Mount Sopris winch. The logging cable is spooled from the winch (see Section 7.2.5.2) and threaded under the bottom sheave wheel on the mast base and over the top sheave wheel on the mast pole. The base plug is inserted into the opening in the mast base. The base plug is to prevent unwanted materials/tools from entering the borehole and is used as a platform on which to rest the logging tool while on the surface. The assembled mast and cable pathway are shown in Figure 28.

For 8-in.-diameter casings, the 8-in.-diameter adapter sleeve is first inserted into the borehole and the mast is assembled as described above.

Figure 28. RAS Logging Setup Showing the Mast Assembly and Cable Pathway

8.3 Zero Depth Set Up

The zero depth set up is a two-step process:

1) Zeroing the sonde in the borehole:

   Determine the depth of the borehole. Set the winch direction to the *Down* position and increase the *Speed* dial above the *Minimum* position in the *Manual* mode. Remove the sonde from the KUTh Field Verifier and move it to the mast over the borehole by applying 12 lbs or more tension on the logging cable. Unspool enough cable off the winch to thread it under the sheave wheel on the mast base and over the top sheave wheel on the mast pole.

   When threaded through the mast, the weight of the sonde is greater than 12 lbs and it would continue moving down in the borehole unless the weight was reduced below 12 lbs. If two people are operating the RAS, the second operator could move the speed dial to absolute *Minimum* to stop the sonde from traveling down the borehole. If the RAS is operated by one person the setup can be accomplished if the sonde is allowed to move slowly down the borehole (when released by the operator). The operator can move to the cab and stop the winch. The winch speed and direction controls can now be used to move the tool so the scribe mark on the detector and the mast base are even. The tool is now zeroed.

2) Zeroing the depth on the logging computer:

   Click the *Preset* button in the LVMON control panel window. In the *Preset* window, click "Set Zero." The *Depth* box on the control panel and *Micro Wiz* multifunction counter should both match and display a zero value. The mechanical counter on the winch should be set to zero. Utilization of this device is important if power to the system is interrupted and the Micro Wiz and computer depth data are lost.

   An alternative method of zeroing the tool must be implemented when the borehole to be logged has casing stickup above ground surface. In this scenario, the distance from ground surface to the top surface of the installed mast base plate shall be measured and recorded. The logging tool is positioned with the scribed zero reference aligned with the top surface of the base plate, and the depth is set to zero in the LVMON program. The tool is moved downward the measured distance and the depth is reset at zero, ensuring that the zero reference on the tool is aligned with ground surface. Logging can then proceed as described in the following section.

9.0 Data Acquisition

The *Hanford Tank Farms Vadose Zone Baseline Monitoring Plan* (DOE 2003) determines the logging intervals for monitoring. Contaminant plumes were measured during baseline logging and prioritized to determine the order, frequency, and depth intervals to be monitored. Borehole monitoring request forms will be provided that specify boreholes, file root names, detector to be utilized, and data acquisition parameters. Data acquisition includes the following activities:

- Logging intervals
- LVMON logging
- Monitoring logging
- Repeat log runs
- Ending log runs

9.1 Sonde Movement

After establishing the zero depth reference, move the sonde to the specified pre-survey gain adjustment depth.

Set the depth direction switch on the winch control to the *Down* position. Note: the *Manual/Computer* toggle is always left in the *Manual* mode. Increase the *Speed Adjustment* as the sonde descends the borehole. The maximum design speed that the Mount Sopris winch can achieve is approximately 25 ft/min. Within 10 ft of the desired depth, slow the sonde speed down to about 5 ft/min. When the specified depth is reached, turn the *Speed* dial to absolute *Minimum* to stop the sonde. The operator should monitor the depth displayed on the Micro Wiz counter to accurately stop the tool at the correct depth. This device has a real-time frequency of display compared to the slow refresh rate of the depth readout in the LVMON program.

After the pre-survey gain adjustment has been made move the tool to the starting depth of the interval to be logged.

If the bottom of a borehole is going to be logged, determine the depth of the borehole first. Lower the sonde at a moderate speed to within 10 ft of the bottom. Slow the sonde speed to 5 ft/min or less. Avoid banging the sonde into the bottom of the borehole or damage to the detector may occur. When the sonde reaches bottom the cable will slacken and the *Tension* display may fall below the 12-lb. alarm limit. When the lower tension alarm is reached, the winch will stop. Raise the sonde slightly above the bottom of the borehole to the nearest 0.5-ft depth interval where the *Tension* display indicates the approximate tool weight of about 60 lbs.

An interval can be logged using two methods: either the sonde can descend or ascend over an interval in the borehole. If logging is descending, start at the upper depth and log to the bottom depth going down. Ascending starts at the bottom depth and logs over the interval traveling upward. Either method can be used. A 0.5-ft overlap should be included at the top and bottom of the log interval so the complete interval is surveyed. Note and record the starting and ending depths.

9.2 LVMON Begin Logging Command

Click the *Begin Logging* command from the LVMON control menu and data acquisition will begin. A graph showing five logs appears in the window. Increase the *Speed Adjustment* until the specified logging rate is indicated on the control panel. Continue to log and monitor all systems.

While logging, count rates in each of five gamma-ray energy windows may be observed as logs. The operator may click the X and / buttons for each log to adjust the display scale as desired. The operator may click the < and > buttons below the logs to display the depth range of choice. Note that only 50 ft of the log may be displayed at one time. The < and > buttons should be clicked until the depth range being logged is displayed. The data points may be observed as they are collected. Alternatively, the operator may observe each spectrum as it is collected. To observe a spectrum, the window containing the spectrum must be brought forward on the computer screen. Clicking on the spectrum where it is exposed around the perimeter of the five-log window brings the spectrum screen forward.

Continue to log until the ending depth is reached. When the ending depth is reached, adjust the winch *Speed* to absolute *Minimum* to stop the winch and click the *Stop* button on the five-logs display. Data acquisition is terminated.

A five-log graph and spectrum are illustrated in Figures 29 and 30, respectively.

9.3 Monitoring Data Acquisition

During data acquisition, the operator should monitor several systems, including the sonde depth, logging speed, cable *Tension*, power, and gain drift.

9.3.1 Speed and Depth

Adjust *Speed* as necessary using the winch controls to achieve the specified logging speed. Two depth indicators are available for the logging operator to monitor the sonde depth in real time. Monitor the *Micro Wiz multifunction counter* located near the winch and the LVMON software window labeled *Depth*. Both displays should match, if not go to the *Header* window in the LVMON program and make adjustments as necessary. The depth displayed by the LVMON on the computer will lag behind the display on the Micro Wiz counter. The Micro Wiz counter should be utilized to monitor the depth of the logging tool.

9.3.2 Tension

Cable *Tension* is displayed on a digital read out located on the winch control panel as the sonde moves in real time during data acquisition. If the sonde binds in the borehole or exceeds 130 lbs, an alarm will stop the winch. In addition, if the *Tension* falls below 12 lbs, an alarm will stop the winch from moving until more weight is applied and the alarm cleared.

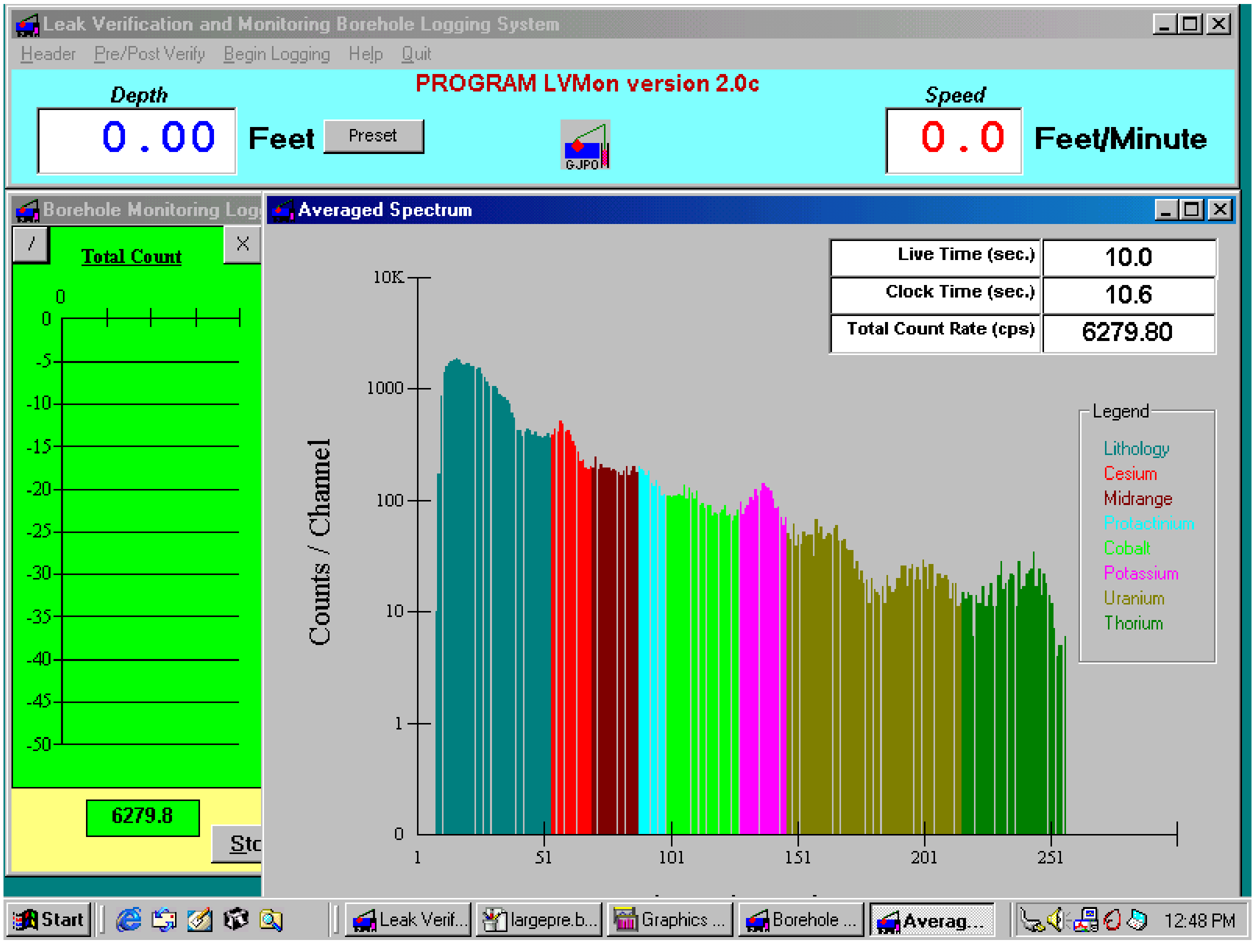

Figure 29. LVMON Logging Program Logging Window Showing Spectrum

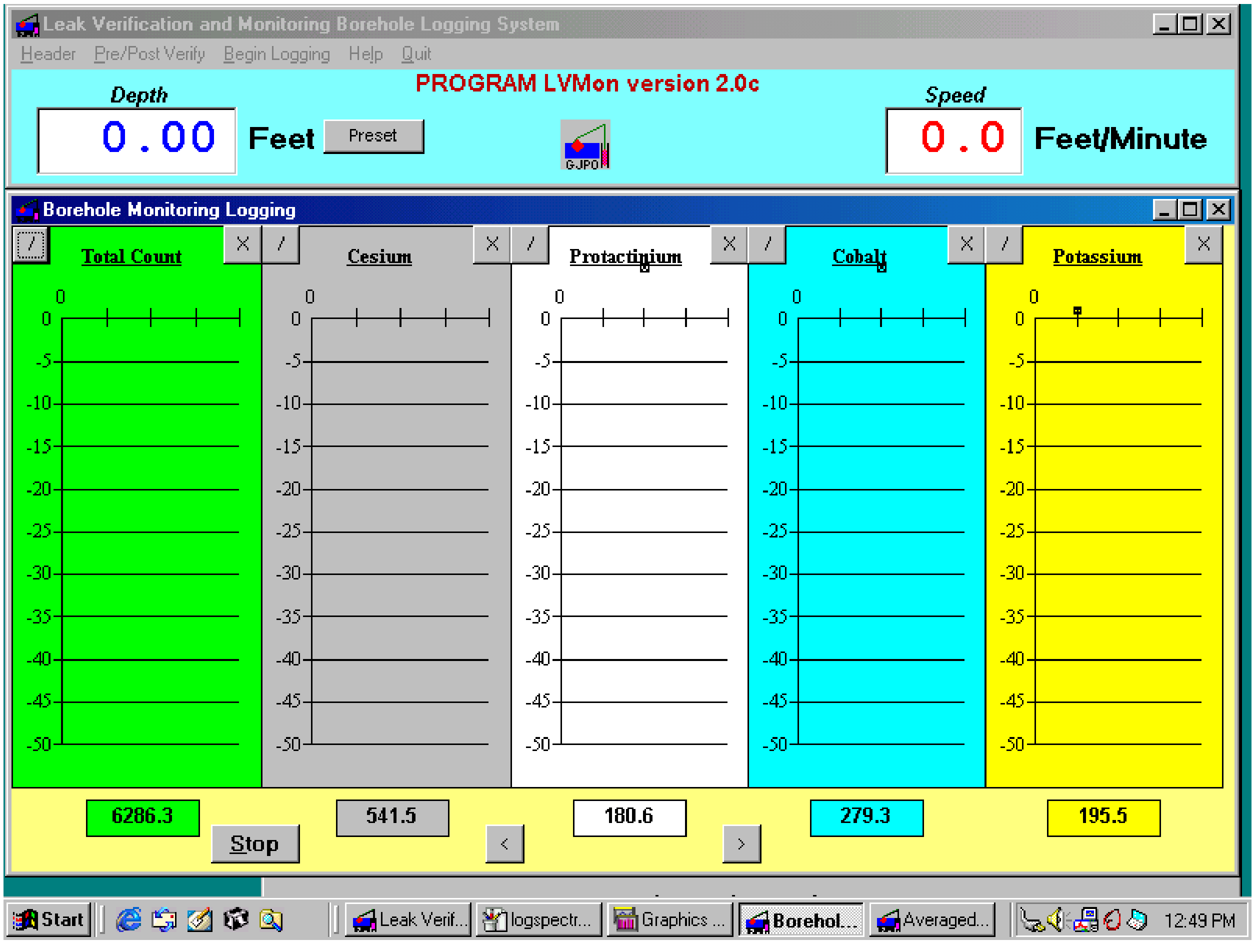

Figure 30. LVMON Logging Program Logging Window Showing Five Window Count Rates

9.3.3 Power

Electrical power is provided by the ProSine inverter. Inside the logging cab is a control panel with the main power switch and a LCD (Figure 15). When the electrical power is ON, the LCD illuminates, showing the condition of the power output. A multi-segment bar graph displays actual output power in watts from the inverter when a load is being operated.

During data acquisition with the motor idling normal LCD readout is 14.4 to 14.6 Volts and between 03 and 06 amps. The AC output when the RAS is operating is less than 250 watts.

9.3.4 Gain

Gain drift will have to be monitored and adjusted as necessary. To adjust gain, consult Section 6.3.8, "Gain." Changes to *Gain* should be made if more than four spectra or about 2 ft are affected by gain shift. Because the logging intervals are short, the *Gain* will probably not have to be adjusted throughout a survey.

Special cases occur in the boreholes where pipe joints are magnetized. These magnetized joints affect the photomultiplier tube causing the gain to shift up or down slightly when the sonde passes through the joint interval. One to three spectra could be affected and can be observed on the five-log window as an increase or decrease in counts in the various windows. Once the joint interval is passed by the sonde, the spectra return to normal. In these conditions, gain will not be adjusted.

9.3.5 Spectra

During data acquisition, the LVMON program provides two screens that the operator can monitor. These screens are described in detail in Section 9.2, "LVMON Begin Logging Command."

9.4 Ending Log Runs

When data acquisition is completed, including the 0.5-ft overlap, the log run is ended. Adjust the *Speed* on the winch control to absolute *Minimum* to stop the detector movement and switch the winch operation from the up or down direction to the neutral position. Click the *Stop* command on the logs display window, and the data acquisition will terminate.

The logging sonde can now be moved to the prescribed depth to collect a *post-survey gain check spectrum* or repositioned to collect a *repeat log run* (Section 9.5, "Repeat Log Runs"). Select the appropriate winch controls settings and move the sonde to the desired depth. The operator should be extremely careful in moving the tool to the surface, and not overrun the zero position and run the cablehead into the tool stop/guide. This may cause overstraining of the mast and may damage the system.

9.5 Repeat Log Runs

A repeat log run is a method of checking the data acquisition system operating the RAS and is used to verify depth control and data quality. Repeat log runs will be conducted once a day using the following guidelines:

1) Any 10-ft interval in a borehole just completed can be a repeat log run.
2) Use the same logging parameters as before including the detector, interval, speed, etc.
3) Record a new *Header* file including a new <file root name> and save.
4) Make a note that this is a repeat interval in the *Comments* area with the *Header* file.

Note: The file root name must be changed before beginning the repeat log run or the data from the previous log run will be overwritten.

10.0 Post Logging Procedures

Post-logging procedures include:

1) Post-survey gain check
2) Determine and record depth return error
3) Data file maintenance
4) Powering down system
5) Equipment storage

10.1 Post-Survey Gain Check

Move the tool to the prescribed depth in the borehole. Select "Pre/Post Verify" from the LVMON program banner. Collect a post-survey gain check spectrum as described in Section 6.3 "Pre/Post Verify". The gain is not during the post-survey gain check. This spectrum will be used during analysis to determine the amount of gain drift that occurred during the log run.

10.2 Determine and Record Depth Return Error

When the sonde has returned to the zero depth reference at the completion of logging as indicated in the LVMON program window and the Micro Wiz multifunction counter, the distance between the scribed tool mark and the top surface of the mast base plate should be measured and recorded in the header comments section. This information will be utilized during analysis and comparison of log data acquired in different surveys.

If the tool reference mark is above the top surface of the mast base plate the error is recorded as +X.XX'; if the mark is below the top surface of the mast base plate, the error is report as -X.XX'. A depth return of greater than +/- 0.1 ft in a 100-ft borehole may indicate problems with the RAS equipment, and the Stoller point of contact should be immediately notified.

10.3 Using the Zip Drive and Data File Maintenance

After the post-survey gain check spectrum is collected, the data files can be copied to a zip disk. Data files are copied routinely to a zip disk after each borehole is completed. Data files are automatically transferred to a zip disk by a command button found on the *Header* window. From the LVMON control menu, invoke the *Header* window.

10.3.1 Using Copy to Zip

Power to the zip drive is supplied from the power distribution strip and turns ON/OFF when the power strip is ON/OFF. A single button on the zip drive illuminates when the power is ON and ejects the zip disk when it is depressed.

Place a zip disk in the zip drive and press the *Copy to Zip* command button on the *Header* window. Spectral data are compressed and transferred automatically from the hard drive on the

PC to a zip disk in the zip drive. A multi-segment bar graph showing the data transfer is displayed on the *Header* window. Wait until the transfer is finished. Remove the zip disk and give it to the Stoller point of contact at the end of the day for data analysis. The program may ask the operator to confirm the creation of the appropriate directory structure on the zip disk before copying files.

10.3.2 Data File Maintenance

Individual borehole spectral data stored in subdirectories should remain on the PC's hard drive until the Stoller point of contact directs that it can be erased. Data files are erased by highlighting the subdirectory where the data are located and pressing the *Delete* key on the PC keyboard. The *Recycle Bin* used by the Microsoft Windows 98 operating system will also have to be emptied to erase data files to make room for additional data on the PC's hard drive.

10.4 Powering Down the RAS

There are several situations affecting if and when electrical power should be shut OFF during RAS logging. They are described below:

Continuous logging done between boreholes or moving between tank farms with the motor ON:

- Between boreholes and tank farms, the 110-Volt electrical power supplied by the ProSine inverter can remain ON as well as all other support systems. This includes the winch, as long as the winch was <u>safely</u> configured to do so prior to vehicle movement.

After logging is complete for the day, or at the end of the day, or stopping for lunch breaks with the motor OFF, the RAS equipment is shut OFF. Use the following sequence:

1) Start to shut down after the spectral data have been transferred to a zip disk. Press the *Quit* command button on the LVMON control menu. The LVMON program closes.

2) Turn OFF the PC. Go to the *Start* button on the tool bar and select *Shut Down* . . . this will turn OFF the PC. Close the laptop on the notebook.

3) Move the two-way toggle switch to the OFF position on the sonde power supply (Figure 18). This will terminate power to the sonde.

4) Turn the power distribution strip OFF. A two-way rocker switch controls the power strip; power is OFF when the switch is flat in the left position and the green light will extinguish. The power strip is illustrated in Figure 18.

5) Turn the Mount Sopris winch OFF. The main power switch for the winch is labeled *PWR Off/On*. The switch is located at the bottom right side of the winch control panel and is turned ON/OFF when the switch is depressed. When the winch is OFF, the *Tension* display is not illuminated.

6) Turn the ProSine inverter OFF. A single switch controls the ProSine inverter from inside the logging cab and is labeled *Power*. Power is OFF in the left position. When electrical power is OFF, the LCD showing power usage is not illuminated. The ProSine control panel is illustrated in Figure 15.

Note: If the ProSine inverter is left on for an extended period of time with the vehicle engine off, the battery system of the RAS may be drained.

10.5 Storing Equipment

This step assumes that the logging cable is already rewound on the winch.

After the electrical power to the support systems on the RAS has been turned OFF, the sonde can be broken down by turning the component subs counterclockwise. Place the protective caps on the ends of the subs and cablehead. Place the subs in their carrying tubes and secure them with the Velcro straps; secure the detector tubes with the elastic strap. Stow the cablehead in the tube located near the base of the winch, and close and lock the tailgate.

Remove and stow the wheel chocks and mast assembly in the side storage boxes located on the truck's camper shell.

11.0 S.M. Stoller Corp. Points of Contact

The Stoller points of contact regarding RAS operation and maintenance are:

Name	Position	Office Number	Cellular Number
Arron Pope	Logging Engineer	(509) 376-6434	(509) 539-9499
Alan Pearson	Project Coordinator	(509) 376-6440	(509) 531-1246
Rick McCain	Technical Lead	(509) 376-6435	
Brian Mathis	Project Manager	(509) 376-6465	

12.0 Glossary

The terms in this glossary are defined as they relate to the RAS and logging operations conducted using the RAS.

Acceptance Criteria: A set of calibration data against which measurements acquired by the RAS are compared for accuracy and repeatability.

Borehole: A small-diameter hole dug in the ground by a drilling rig and completed using steel casing of various sizes for monitoring a portion of the vadose zone around single-shell tanks.

Calibration: A process where a series of measurements are recorded by the RAS from a model of known strength and composition from which concentrations and error measurements can be determined.

Clock Time: Real time.

Count: A pulse of radiation.

Dead Time: The time the system requires to process detector responses. Dead time is calculated by subtracting live time from clock time (real time) and dividing the result by clock time.

Detector: A device that senses the interactions from radiation and converts the interaction to a measurable signal.

File Root Name: A unique naming structure used by the LVMON logging program to record and identify each tank farm, tank, borehole, and log run.

Gain: A factor by which a pulse is amplified.

Galling: A rough surface.

Header: A data file used by the LVMON logging program where pertinent information are input including set up parameters, borehole location, and depth.

KUTh Field Verifier: A portable devise manufactured by the AEA Technology, QSA, and used in the field to check the day-to-day performance of the RAS. The device contains a fully encapsulated mixture of minute quantities of naturally occurring radioactive elements ^{40}K, ^{238}U, and ^{232}Th. Spectral gamma-ray data recorded from the verifier is an integral part of the RAS logging operations. These spectra are compared to acceptance criteria.

Live Time: The time a system is able to process detector pulses. Live time = real time – dead time.

Logging: The process of recording spectral gamma-ray data using the RAS.

Log Run: A single logging event where spectral data are recorded from a specific borehole and depth interval using the RAS. Data are recorded using a unique file root name, numbered sequentially, and bound by a start and stop depth.

Post-Survey Gain Check: The process of collecting a spectrum at the end of a log run in the borehole to check for gain drift.

Pre-Survey Gain Adjustment: The process of collecting a spectrum prior to a log run in the borehole to adjust the gain.

Pre-Survey Verification: The process of collecting a spectrum at the beginning of the day in the KUTh Field Verifier to record and check the performance of the RAS. Verification spectra are compared to acceptance criteria.

Pulse: Emitted energy that a detector can count given enough time.

Pulse Height Analyzer (PHA): An electrical device that collects counts from a detector and converts them into a record as a function of energy. Graphic displays are spectra.

Real Time: Clock time.

Repeat Log Run: A method of observing the performance of the RAS by comparing spectral data and depth control measurements between one log run and another.

Sheave Wheel: A mechanical device used for hoisting, guiding, or routing a cable.

Sonde: An electrical device containing a detector, PHA, and other electrical apparatus used for measuring gamma-ray energy that can be conveyed inside a borehole.

Spectra: Recordings of physical measurements collected with a sonde that can identify various gamma-ray energies. Spectra can be graphically displayed and saved as files on a computer using the LVMON logging program.

Spooling: A process where a cable is wound on a winch.

Total Count Rate: The sum of radiation pulses collected by a single spectrum, divided by its collection time, and expressed in units of counts per second.

Vadose Zone: A geologic term used to describe the interval that exists above the water table and below the ground surface.

Zip Disk: A portable magnetic disk used to compress and transport large numbers of spectral files between the field and office.

13.0 References

U.S. Department of Energy (DOE), 2001. *Hanford Tank Farms Vadose Zone Monitoring Project, Initial Calibration of the Radionuclide Assessment System*, GJO-2001-237-TAR, prepared by MACTEC-ERS for the Grand Junction Office, Grand Junction, Colorado.

U.S. Department of Energy (DOE), 2003. *Hanford Tank Farms Vadose Zone Monitoring Project, Baseline Monitoring Plan*, GJO-HGLP 1.8.1, Revision 0, prepared by S.M. Stoller Corp. for the Grand Junction Office, Grand Junction, Colorado.

U.S. Department of Energy (DOE), 2005. *Hanford Tank Farms Vadose Zone Monitoring Project, Preventive Maintenance Procedure for the Radionuclide Assessment System*, GJO-HGLP 1.8.4, Revision 1, prepared by S.M. Stoller Corp. for the Grand Junction Office, Grand Junction, Colorado.

Appendix A
RAS Logging System Operation

RAS Logging System Operation

This appendix is for individuals with prior experience operating the RAS logging vehicle and familiar with the logging process. Data acquisition using the RAS is outlined below.

Part 1 — Equipment Set Up and Preparation:

1) Position the vehicle 10 to 50 feet (ft) from the borehole.

2) Position the mast assembly on the borehole and assemble the sonde and cablehead. Slide the sonde into the KUTh Field Verifier.

3) Turn ON the power inverter and support systems. Set the winch for a safe configuration before turning power ON.

4) Turn power to the sonde ON. Power to the sonde must be ON for 30 minutes prior to data acquisition.

5) Turn ON the logging computer (PC) and invoke the Leak Verification and Monitoring Logging Program (LVMON).

Part 2 — Header Completion:

1) Invoke the *Header* window from the LVMON program. Complete all information entries and file root name. Click *Save + Close* to save the header data as <file root name>.HDR. on the PC's hard drive as in the C:\LogData\FarmID\TankID\HoleNo\ data file.

Part 3 — Pre Verification:

1) Invoke the *Pre/Post Verify* window from the LVMON program. Set the *Gain Slider* to the initial value used for that sonde. Input 300 seconds (sec) acquire time and denote as *Pre Verify*. Click *Start* to observe the accumulation of a spectrum.

2) Allow enough counts to accumulate to observe the potassium-40 (K-40) peak. The K-40 peak should fall within its highlighted window in the spectrum. If the peaks are not in the correct place, adjust the *Gain Slider* a small amount up or down and click the *Clear* button. Repeat this process until gain is adjusted and the peaks appear with their highlighted windows.

3) Gain adjustment may be performed during the 30-minute warm-up period. However, verification spectra cannot be collected during this time. At the end of the warm-up period, examine the spectra in the display to confirm that the peaks are within the proper windows, and make any final gain adjustments. Set the acquire time in accordance with the following table and collect the pre-run verification spectra.

Detector	Count Time
Large	200 sec
Medium	600 sec
Small	1000 sec

4) Click the *Save Cal File* button to save the accumulated spectrum as <file root name CAB>.CHN from the *Pre/Post Verify* window. Click *Close* to exit.

Part 4 — Logging:

1) Determine the depth of the borehole.

2) Set the winch direction for *Down*. Move the sonde over the borehole. Unspool the cable by applying 12 or more pounds of pressure against the winch. Thread the logging cable through the sheave wheels and rest the sonde on the mast plug.

3) Zero the sonde in the borehole. Press the *Preset* button then *Set Zero* from the LVMON control panel.

4) Move the tool to the prescribed pre-survey gain adjustment depth. Perform the pre-survey gain adjustment.

5) Lower the sonde to the start depth, click *Begin Logging* from the LVMON control panel, and set the sonde speed. Data acquisition begins collecting spectra as sequentially numbered <file root name>.CHN files.

6) While logging, observe the five log or spectrum windows and monitor the support systems.

7) When the end depth is reached, stop the winch and click the *Stop* button from the logs display.

8) Move the tool to the prescribed post-survey gain check depth. Perform post-survey gain check.

9) Move tool to the surface and check zero return error.

10) Remove the sonde from the mast and spool the logging cable ON the winch.

Part 5 — Data File Maintenance:

1) Invoke the *Header* window from the LVMON program. Place a zip storage disk in the zip drive and press the *Copy to Zip* button from the *Header* window. When the file transfer is finished, click *Close* to exit.

Part 7a —Move to New Borehole:

1) If done monitoring for the day, skip this section and go to Part 7b.

2) Leave all electronics on, and stow sonde (with cablehead attached) in the verification rack. Close tailgate. Disassemble and stow mast.

3) Move to new borehole.

4) Change header to include information for the new borehole per Part 2.

5) Follow procedures starting from Part 4.

Part 7b — Take Down and Move:

1) Click *Quit* from the *Header* window to close the LVMON program. Exit Windows 98 and turn OFF the PC.

2) Turn OFF power to support systems. Disassemble and stow the sonde and mast. Park for the day.

Part 8 — Turning Over Data:

1) The zip disk with the data files and completed borehole monitoring request forms are given to the Stoller point of contact at the end of the day for analysis.

Appendix B
DIGITEC Display Programming Instructions

Appendix C
Micro Wiz Multifunction Counter
Programming Instructions